JUNE 1952
METAL PROGRESS
AN SOCIETY FOR METALS

IN THIS ISSUE

As I was saying—

THERE ARE MANY important dates in a business life that one remembers when the past flows through his mind.

The most recent important date was April 17, on which I received a communication from Dr. Aldo Dacco, President of Associazione Italiana di Metallurgia, telling me that the President, Dr. John Chipman, had been unanimously selected by the Award Committee to be the recipient of the Losana Gold Medal. This award is the only one existing in Italy and is considered the highest distinction in the field of metallurgy.

The Associazione Italiana di Metallurgia in 1950 created the Luigi Losana Award as a memorial to Professor Losana, a distinguished Italian metallurgist who died in 1947. It will be awarded every two years to a prominent metallurgist, Italian or foreign, who has made substantial contributions to the knowledge of metals.

The first Losana Medal was awarded in 1950 to the well-known French scientist and educator, Prof. George Chaudron.

The second Losana Medal will be presented to Dr. Chipman during the National Congress of the Associazione Italiana di Metallurgia. The ceremony will be held in Italy, September 20th to 23rd.

The Losana Award Committee, according to its rules, designates the country to which the Award is to be assigned. May I quote from Dr. Dacco's letter: "I have the pleasure to let you know that at the last meeting, the Committee has unanimously decided to award the Losana Gold Medal for 1952 to an American metallurgist. This designation is a recognition of what your country has done in the field of metals. Furthermore, this intends to be an expression of our feelings of gratitude for the reception you gave to our conferees to the World Metallurgical Congress, and for the help the United States of America is giving to Italian industry."

A second letter was also received on April 17 stating that Dr. Aldo Dacco would arrive in America soon to communicate officially to Dr. Chipman, on behalf of the Losana Award Committee, that he had been unanimously selected to be the recipient for 1952.

So that day became a bright spot in the history of the American Society for Metals and its President, and is added to the many other dates that have marked the years of progress of the Society.

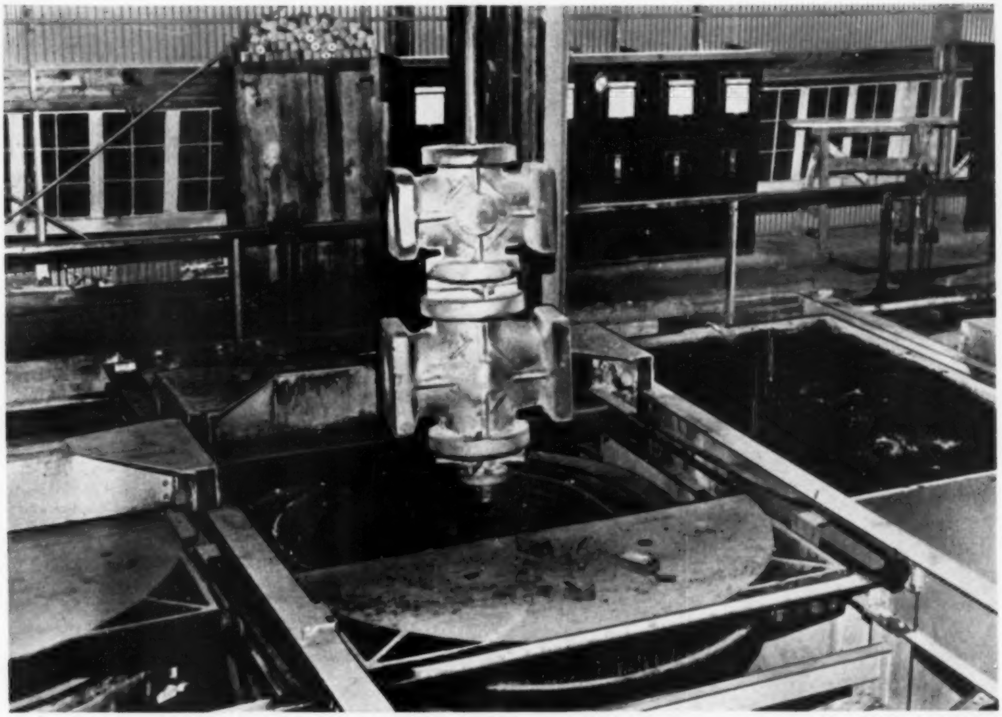
Congratulations to Dr. Chipman on this signal honor by our overseas friends. We know well that all America will be proud and pleased with Dr. Chipman's cordial and dignified representation of the American metals industry. He will be an outstanding ambassador of good will, and will convey to Italy and the Associazione Italiana di Metallurgia America's and the 's firm, strong friendship, and portray the high esteem and regard in which our fellow Italian metal scientists are held.

So congratulations, Dr. Chipman! It couldn't have happened to a better man!

Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS



Part of heat-treating dept., Texas Electric Steel Casting Co., Houston. Valve body casting leaving furnace after slow cooling. All furnace temperatures are controlled by Micromax instruments in background.

Round-the-clock Heat treatment?

Tesco does it under Micromax control

Twenty years experience in the manufacture of heavy castings gives the Texas Electric Steel Casting Co. a vast store of information about all kinds of heat-treating equipment. And one fact this experience clearly shows is that they can rely on Micromax automatic control to back them up every time . . . even when they must hold temperature to a ± 10 F tolerance!

Tesco has found Micromax dependability especially valuable in 24-hour, 7-day-a-week operation. Its automatic standardizing protects the basic accuracy of the entire instrument, removing all need for everyday adjustment. Its micro-responsive control anticipates changes, regardless of cause, and heads off their effect, so as to hold heating, soaking and cooling temperatures as specified.

This smoother performance is available for all furnaces—car-bottom and vertical, such as Tesco's . . . continuous furnaces . . . controlled atmosphere installations; and for practically *any* product where uniformity and *economy* are important.

In solving such problems, you may select Micromax instruments, as Tesco did, or Speedomax electronic recording controllers. Both instruments are available in either the strip chart or round chart form. Both can provide any control action needed.

Our representative will be glad to help you investigate the instrumentation for proper control of your heat-treating problems. Write our nearest office or 4927 Stenton Ave., Phila. 44, Penna., for catalogs and information.

LEEDS & NORTHRUP CO.

INSTRUMENTS • AUTOMATIC CONTROLS • FURNACES

Jrl Ad ND44-33-620(3)

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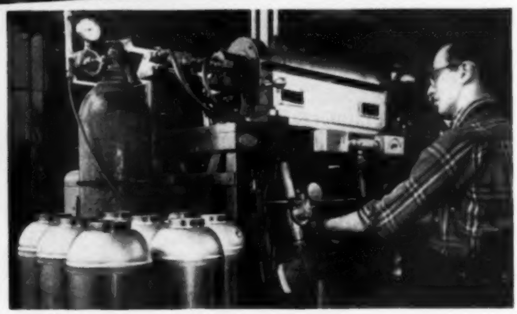
500 psi hydrostatic pressure tests, 43% higher than usual test requirements, are standard procedure with Pyrene extinguishers before leaving the production line (high pressure tests of 1000 psi show no breakage).

Semi-automatic Heliwelding of type 301 stainless steel is a high-speed operation at the Pyrene Manufacturing Co. of Newark, N. J. Here, jig-mounted stainless steel cylinder bodies are longitudinally weld-seamed at 90" per minute.

Finger-tip controlling two No. 10 Radiagraph arms, one operator simultaneously Heliwelds two 1000 psi pressure-tested end seams in 41 seconds.



Silent fireman with a 40-foot reach...

HELIWELDED PYRENE FIRE-STOPPER

Discharging an easily directed 40-foot stream, the new stainless steel gas-cartridge-operated Pyrene Water Type Fire Extinguisher eliminates two important fire protection problems ... annual recharging and the danger of working with acid ... and its price is comparable to older soda-acid equipment.

Pyrene's answer for meeting the cost problem? Lighter weight equipment, stronger-made with Airco's semi-automatic Heliwelding process.

Why? Because Heliwelding, with its inert gas shield, eliminates the need for flux. No slag is formed, welds are exceptionally strong and clean. Gas shielded electrodes provide a highly concentrated arc permitting high-economy production welding with a minimum of distortion.

If you're welding thin sections of the "problem" metals, stainless steel, aluminum, on a production basis, Airco Heliwelding can help you. Find out how from your nearest Airco office. Please address Advertising Department, 60 East 42nd Street, New York 17, N. Y. for your copy of ADC-709: Heliwelding.

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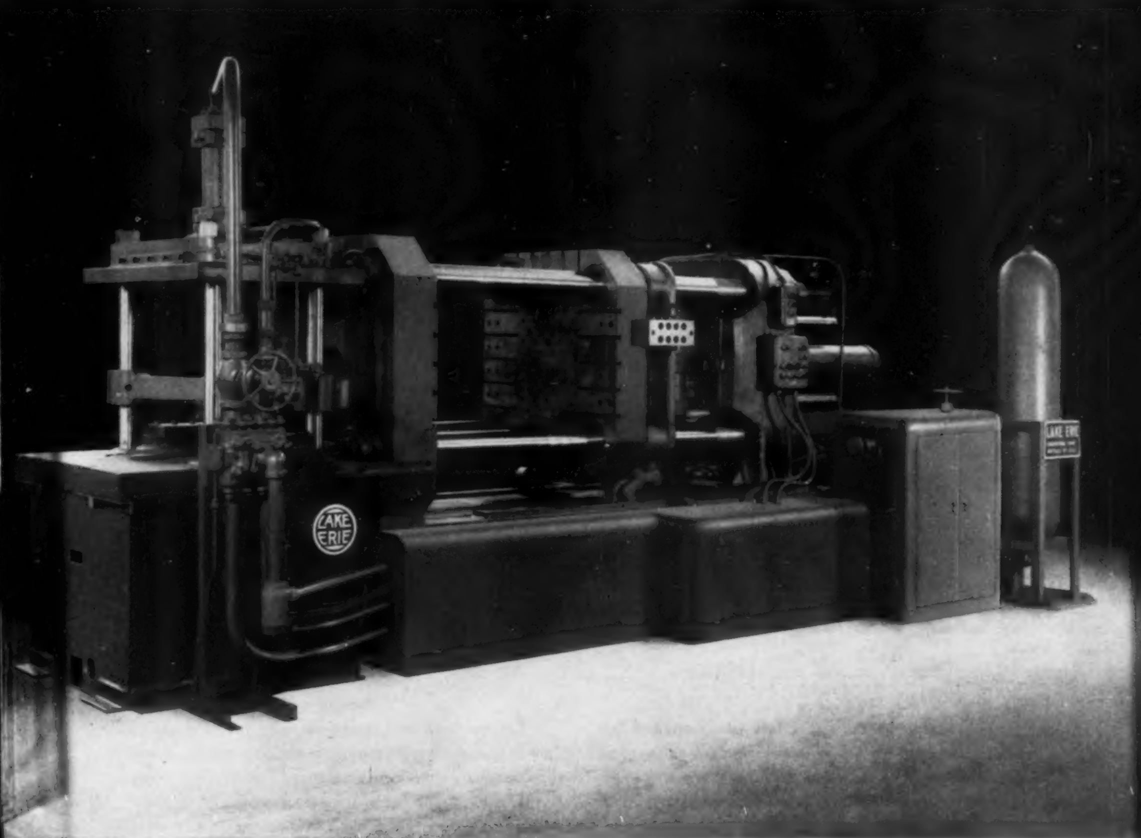
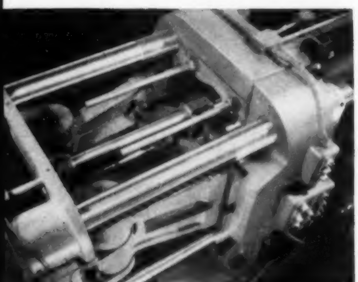


Model H-80. Hydraulically operated. 800 ton locking pressure. Push button controlled.

Lake Erie Die Casting Machines set new standards in hourly production and finished casting costs



The "Wedge Cam Toggle" is an exclusive Lake Erie Engineering design.

"WEDGE CAM TOGGLE" The revolutionary Lake Erie "Wedge Cam Toggle" has provided a new standard of comparison for increased die casting production. This self-compensating toggle clamp automatically takes up clearances in the dies due to contraction and expansion of the molds during production or shut-down periods, and, at the same time, engages and disengages easily without binding. This is accomplished by the use of a circular cam contact surface together with rolls which guide the toggles during engagement and disengagement. The toggle action is actuated by a hydraulic cylinder which provides smooth, rapid opening and closing.

"PRESSURE PAC" This patented unit consists of automatic pressure booster in the hydraulic circuit between the accumulator and the injection cylinder. It provides the necessary pressure to feed the shrink or compress the porosity at the time of solidification of the metal. The standard unit is arranged for 2-to-1 pressure increase. Special units are available for higher pressure ratios.

Flywheel — Centrifugally-cast.

Can forming die — Centrifugally-cast.

—with AMPCO* METAL

Marine reversing gear component — Sand-cast.

Sixty times longer service life and still going strong. That's the story of the slide blocks used in Zig Zag Wire Formers. And the service is tough too — involves high speeds, severe shock loads.

As a result, 25 Ampco Metal parts are used in the Zig Zag Wire Former. The company reports that in 5 years no Ampco Metal part has been replaced or adjusted in any machine, despite high operating speeds and tremendous shock loading.

Mr. Harry H. Norman, Chief Engineer of the Zig Zag Spring Company, says that the long-wearing properties of Ampco Metal have contributed substantially to the success of their Spring Former.

Take a look at your wear problems. Perhaps Ampco Metal is the low-cost solution. Easy to use because it is available in practically any form required—sheet, plate, sand and centrifugal castings, forgings, bars, tubes, welding wire and electrodes. Consult your nearest Ampco field engineer or write us for further information.

*Reg. U. S. Pat. Off., Ampco Metal, Inc.

Bushings — Centrifugally-cast Ampco Grade 18 standard bars.

Tear out this coupon and mail today!

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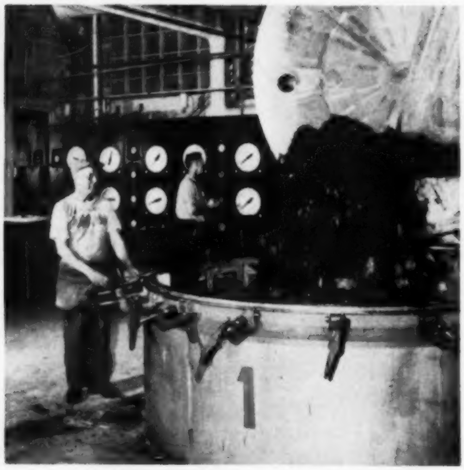
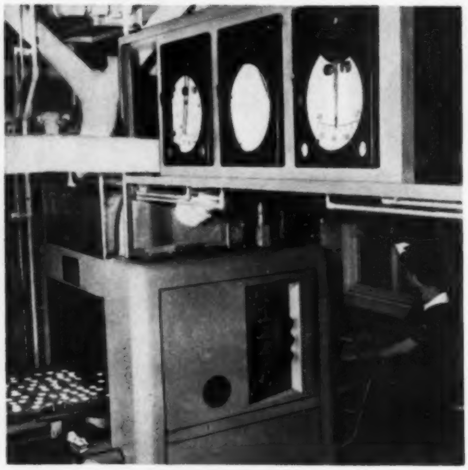


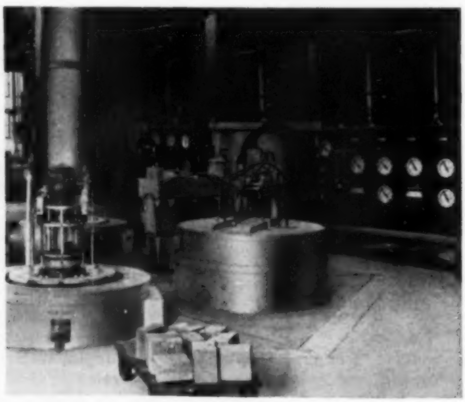
EXACT COLOR MATCHING *is important to quality carpet manufacturing . . . and depends, in part, upon the rigid maintenance of proper time and temperature schedules in the raw stock dye kettles. These* ***ElectroniK*** *controllers keep the schedules uniform and reproducible.*



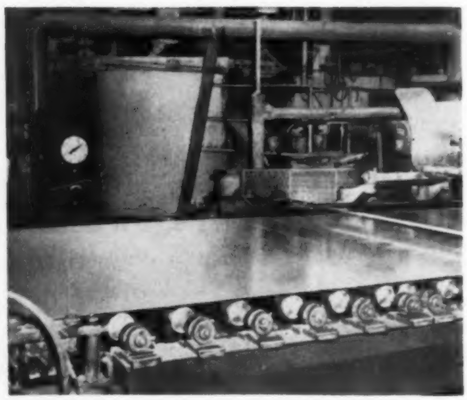
AUTOMATIC ENROBER CONTROL *system keeps the temperature of chocolate at precisely the proper point . . . for the mass production of quality candy. This same plant uses an automatic long cycle tempering to condition the chocolate before it enters the enrobers.*

For all of industry . . . *especially*

Instruments



HIGH QUALITY *heat treating is a must for the dies used in precision forging of jet-engine turbine blades. These* ***ElectroniK*** *instruments provide the sensitive, accurate control of treating temperatures necessary for the meeting of exacting specifications.*



HOLDING PRODUCT QUALITY *at a high level is one of the many important functions of Brown instruments. The pH controller shown with this Fourdrinier machine is part of a complete control system which helps insure continuous production of top quality sheet and board.*

Engineering Digest

OF NEW PRODUCTS

POLISHING AND BUFFING: The Hammond continuous rotary automatic machine permits the automatic polishing and buffing of parts ranging in size from 1/8 to approximately 12 in. in diameter. The parts that can be finished range from automotive and household appliance parts and trim, cookware, plumbing and hardware fixtures, to compacts, jewelry cases and fountain pen barrels. The basic machine has a 46-in. diameter table. The fixtures revolve as they pass the buffing wheels, presenting all outer, top, and side surfaces of the work to the belt or wheel for finishing. For ease in loading and unloading the work piece, fixtures do not revolve at the operator's station

at the front of the machine. Rotating speed of the work spindle is variable with a 3-to-1 range. A separate motor drive is independent of the table rotating drive. The table rotating speed is also variable with a 3-to-1 range, providing production of from 1000 to 3000 pieces per hour, depending on the dwell time required to finish the work piece. The photograph shows the Model C-46-40 equipped with 40 work spindles and work-holding fixtures for buffing both straight and cross die-cast handles.
For further information circle #1211 on literature request card on p. 32B

WELDING FLUX: Fluxes made by Special Chemicals Corp. for hard soldering, brazing and welding have been improved to overcome several problems usually encountered. Addition of an anti-crystallant has prevented crystallization from taking place. This is especially important for users of paste flux, which crystallizes when unused for any length of time, especially in winter, and previously had to be heated and dissolved or reground to be usable. Another compound added to the flux is phosphate. This gives the fluxes better "bite", primarily on stainless steel, and better capillary action when required in a joint.
For further information circle #1212 on literature request card on p. 32B

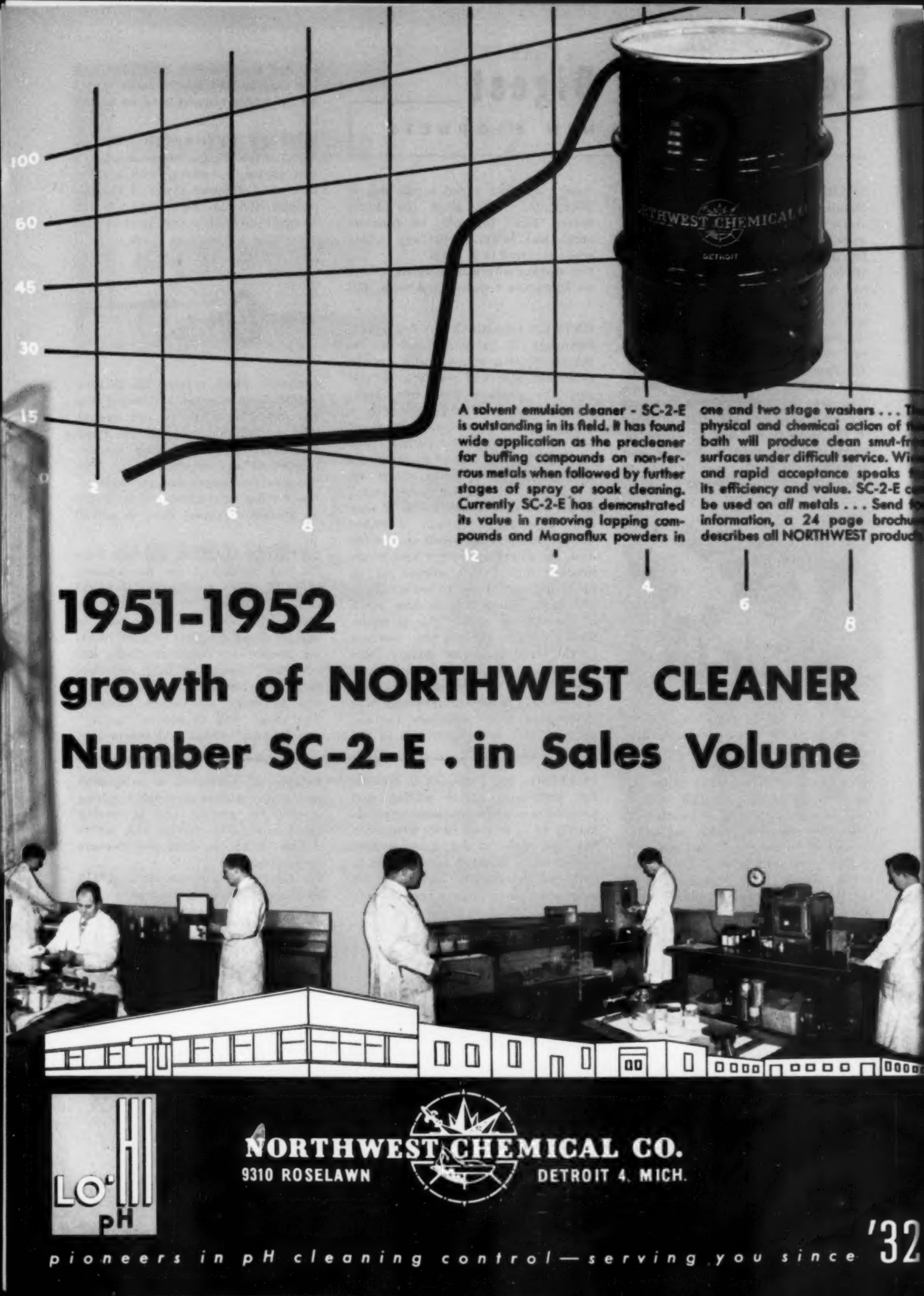
OXYGEN GENERATOR: Joy Manufacturing Co. has announced the development of a semi-portable oxygen generator that will enable industrial users to produce their own high-purity oxygen. The generator is a compact unit requiring a space of 600 cu.ft. (8 by 7½ by 10 ft.). The machine does not depend on chemicals and nothing is consumed except air and power. Models are contemplated in the size range from 0.5 to 12 tons daily capacity of oxygen of 99.5% purity. Despite the small size of the unit, the company reports that it can produce high-purity oxygen at an operating cost of five to ten cents per 100 cu.ft., depending on how much of the time it runs. This is equivalent to $12 to $24 per ton. Savings to the consumer come mainly from eliminating oxygen transportation. Heart of the Joy oxygen generator is a series of automatic reversing heat exchangers which eliminate the expense of chemical purification of the air and contribute to high efficiency.
For further information circle #1214 on literature request card on p. 32B

SURFACE PYROMETER: Pyrometer Instrument Co. has announced a new surface pyrometer with a selection of 14 different types of thermocouples and extension arms. It can be equipped with a new quick-change

connector which permits the thermocouples to be snapped and locked onto the extension arms in one second, with no tightening needed. The Pyrolock-swivel permits locking thermocouples at any desired angle. Five temperature ranges are available.
For further information circle #1215 on literature request card on p. 32B

CATHODE ALLOYS: Superior Tube Co. has announced the development of an entirely new series of nickel cathode alloys to be known as the Cathaloys. The new series includes special alloys designed to meet exacting present-day requirements for low interface impedance, high emission, long life, improved tube reliability and increased mechanical strength. The series will consist of "active" and "passive" alloys. At the present

PLATING: The Frederick B. Stevens full automatic barrel plating and processing machine measures approximately 48 ft. long by 12 ft. wide when installed with the automatic loading equipment. Because of its built-in unloading feature, the addition of the automatic loader makes the machine capable of becoming a component part of any modern materials handling system for plating and processing small parts. This feature also makes it possible to cut costs and increase production.
For further information circle #1213 on literature request card on p. 32B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NORTHWEST CHEMICAL
DETROIT
A solvent emulsion cleaner - SC-2-E is outstanding in its field. It has found wide application as the precleaner for buffing compounds on non-ferrous metals when followed by further stages of spray or soak cleaning. Currently SC-2-E has demonstrated its value in removing lapping compounds and Magnaflux powders in
one and two stage washers . . . Th physical and chemical action of t bath will produce clean smut-fr surfaces under difficult service. Wi and rapid acceptance speaks its efficiency and value. SC-2-E c be used on *all* metals . . . Send f information, a 24 page brochu describes all NORTHWEST produc
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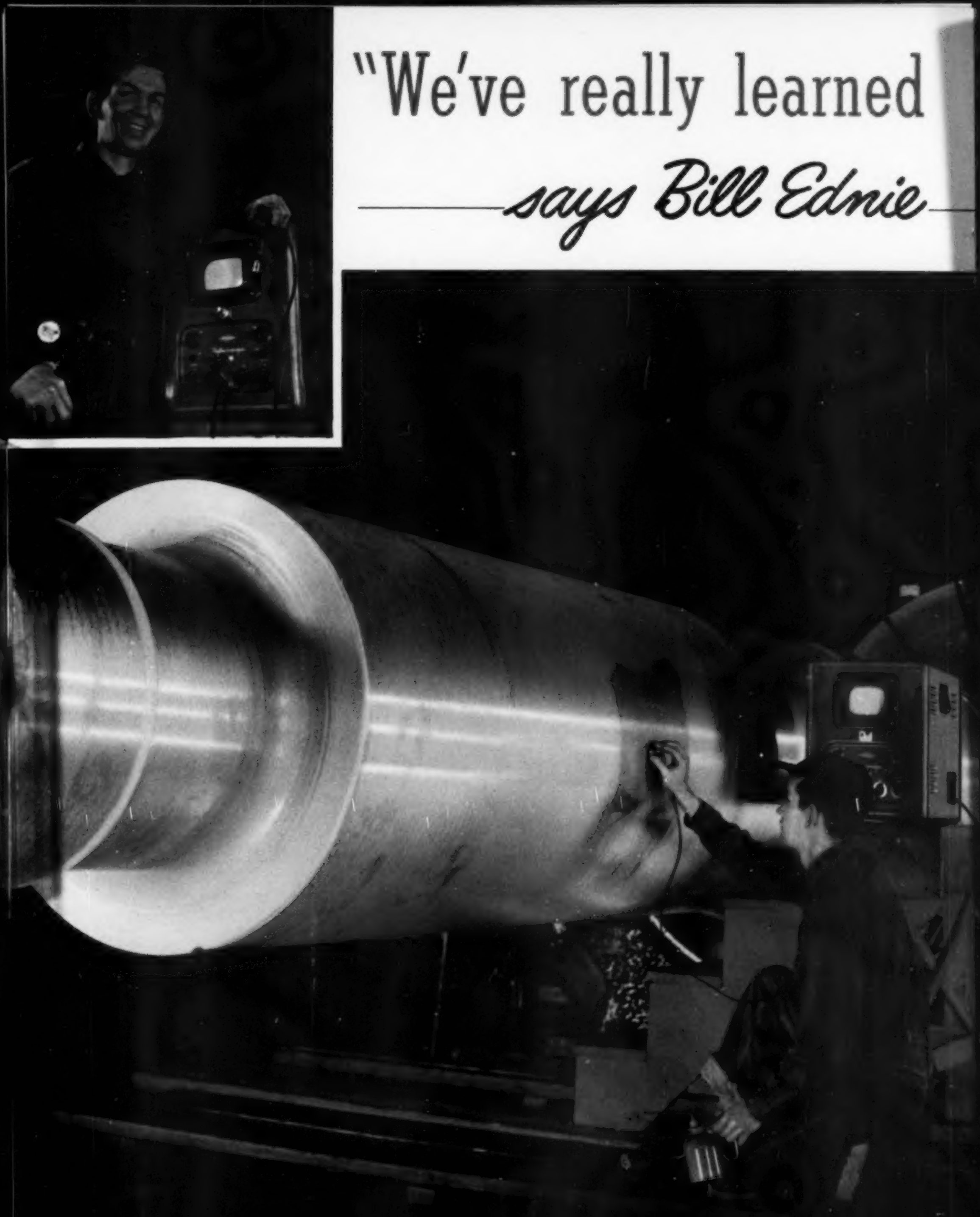
pioneers in pH cleaning control—serving you since '32


"We've really learned
says Bill Ednie
UNITED STATES STEEL

how to control quality"

U. S. STEEL INSPECTOR

● You'd want to meet Inspector Bill Ednie if you visited our Homestead District Works Forge Department. He has been an inspector now for 13 years. His father was a U.S. Steel Inspector at Homestead, too—back in the days when you tested forgings with a light bulb and a ball peen hammer.

Now, of course, Bill has the advantage of amazingly accurate test equipment, but he still has to be right on his toes to analyze the complex inspection data. In other words, he is the man who actually "signs out" the forging, and makes sure that it meets every specification.

If you had talked to Bill Ednie when we took these photographs, the conversation might have gone like this:

YOU: *"How much does this forging weigh?"*

EDNIE: "86,000 pounds. It's a steam turbine generator shaft."

YOU: *"Is this the first inspection made on it?"*

EDNIE: "No. This is one of the last. Right after it was forged, we 'barked' it—put it in a lathe and took enough metal off to get a smooth surface. Then I made the first sonic test and found the piece was free of thermal ruptures and internal voids."

YOU: *"How does this sonic tester operate?"*

EDNIE: "Well, it sends a pulse of energy through the forging and it bounces back from the other side. The trick is analyzing the trace on the oscilloscope to be sure the piece is sound all the way through. We use this test for quality control during manufacture."

YOU: *"Do you make other tests?"*

EDNIE: "Always. After we finish the first machining operation, we go in with a trepanning tool and get test bars. Then we send the bars to the lab for tensile and Charpy impact tests and micro tests to check grain structure and cleanliness of the metal."

YOU: *"How about the center of the piece?"*

EDNIE: "We usually bore and ream a hole all the way through, then give the entire inside a boroscope examination. This way, you can actually *see* that the center of the forging is sound."

YOU: *"Does that about wind it up?"*

EDNIE: "For this generator shaft, yes. But inspection often gets more complicated on other forgings. Take a steam turbine rotor. After we bark it, it goes into the heat treating furnace for over 200 hours. Then it's tensile tested, bored, final rough machined and stress relieved. And after that, it gets the heat-indication or stability test."

YOU: *"What's that?"*

EDNIE: "It's a test to show how the rotor will behave in actual use. We put the rotor in a combination lathe-furnace—it's a furnace built on a lathe. The rotor is revolved for about 100 hours at the temperature it will encounter in actual service. If it passes this test, it won't change shape after it's installed."

YOU: *"How do you know what tests to make?"*

EDNIE: "That depends on the end use of the forging. Sales, Technical, Operating and Production men all work with the customer to determine what tests are needed for any one job.

"Sometimes we make scleroscope tests—that's a way to check hardness without marking the piece. Other times we run Magnaflux tests. All in all, we have the most modern testing equipment available."

YOU: *"How do you figure that all this inspection pays off for the customer?"*

EDNIE: "I think the biggest thing is that—because of better inspection—we've been able to develop better production methods. This naturally means fewer rejects, so our customers get better delivery.

"We've really learned how to control quality, and that's what the customer wants. This shop has been going for a long time, and every one of the gang has found that satisfied customers mean more work for all of us."

• • •

When you buy Quality Forgings from United States Steel, men like Bill Ednie work on them. We'll stack their work up against the finest in the land, and we're confident in our ability to furnish the highest quality forgings made. Please send your inquiries to United States Steel Company, 525 William Penn Place, Pittsburgh 30, Pa.

USS

Quality FORGINGS

heavy machinery parts—carbon, alloy, stainless

electrical and water wheel shafts

hammer bases and columns

marine forgings

Facts you should know about U·S·S CARILLOY STEELS

U·S·S metallurgists can help you turn out quality products with lean alloy steels

● Thousands of manufacturers have lately been forced into using lean alloy steels, instead of the rich alloys they are accustomed to. Some have found that the transition from rich to lean alloy has presented a few problems. However, satisfactory results *can* be obtained from lean alloy steels, if heat-treating and fabricating methods are adjusted to suit these steels.

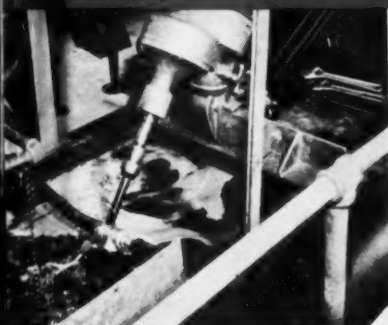
If you are having trouble perhaps we can help you. We'll be glad to analyze your heat-treating and fabricating methods and give you specific advice based on our wide experience in this field.

There is no charge for this service. It's part of our continuing program to help all of our customers get the most out of the steels they're using.

We quote two well-known manufacturers who have benefited from our suggestions:

"Results with lean alloys equal to those with high alloys"

—UTICA DROP FORGE & TOOL CORPORATION



"... with improved quenching ... we obtain more satisfactory hardening."

"Forging is easier with lean alloys."

● Utica Drop Forge & Tool Corporation developed an improved method of quenching and tempering with the help of U·S·S metallurgical assistance. Mr. C. E. Wilderman, Vice President of the Tool Division, has this to say: "With your help, our metallurgists have developed heat-treating methods that enable us to get results with lean alloys equal to those obtainable with high alloys. Daily control tests show that our adjustable-end wrenches surpass the Federal Specifications by several times (for the 12-inch wrench—25,000 in. lbs. of torque as compared to 7,650 in. lbs. required). We know a good deal of the credit for these high torque ratings is due to the improved heat treatment."

"Improved quenching... Increased production..."

—JEFFREY MANUFACTURING COMPANY

● Mr. C. S. Thomas, Chief Metallurgist at Jeffrey Manufacturing Company, says, "We used to have trouble with uneven hardening.

"Now, with an improved quenching process recommended by U·S·S engineers, we get uniform hardness without exception. The new method speeds up quenching and makes it easier to quench large parts, such as 100-pound, alloy steel gears.

"We gain increased production and reduce the chance for human error. In addition, we obtain more satisfactory hardening."

An improved method of quenching, recommended by U·S·S metallurgists, is used at Utica Drop Forge & Tool Corp.

Our engineers and metallurgists will bring to the solution of your problems the latest ideas and techniques in the working and treating of steel. We urge you to draw freely on their services. Just call your nearest District Sales Office, or write to United States Steel Company, 525 William Penn Place, Pittsburgh 30, Pa.

USS

TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

time the company is completing its tests on the first two of the new alloys, a 0.1% aluminum nickel alloy and a 4% tungsten nickel alloy.
For further information circle #1216 on literature request card on p. 32B

ROLL SURFACE TEMPERATURES: High precision in measuring roll surface temperatures, from —40 to +450° F., is obtained with the temperature measuring head developed by The Foxboro Co., and used in conjunction with a high speed recording

controller. The temperature-sensitive element is a miniature resistance bulb which rides lightly on the surface of the roll. The entire unit weighs less than one pound.
For further information circle #1217 on literature request card on p. 32B

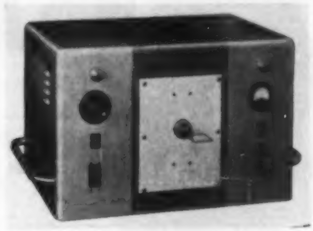
ELECTRONIC RECORDER: The new Olsen Model 51 electronic recorder incorporates the high speed and accuracy inherent in the electronically controlled null balancing system which utilizes specially adapted atcotran differential transformers built into the housing. This null system rotates the recorder chart drum in direct proportion to the strain or deformation of the specimen under test. The testing machine produces a stress coordinate by horizontal movement of the non-clog pen of the recorder. Sensitivity of this instrument is 0.05% of full scale for each range; accuracy of strain coordinate is plus or minus 1/5 division (0.2% of full scale); accuracy of stress coordinate is equal to that of the testing machine. Standard instrumentation is available for motion detectors for magnifications ranging from 1000:1 to 1:1. Magnifications are instantly available by flip of a switch, without gear change of any kind, and may be changed without stopping the test.
For further information circle #1218 on literature request card on p. 32B

MAGNETIC PROBE: The General Scientific magnetic probe is no larger than a fountain pen. Point of the magnet is extended or retracted from its case by turning the end-knob;

strength of the magnet can be controlled by the amount of extension. In addition to obvious uses, the probe has been applied in testing surfaces for magnetic properties of the base material below.
For further information circle #1219 on literature request card on p. 32B

CEMENTED CARBIDE: A new grade of carbide, S-6, by Newcomer Products, Inc., has been developed for extra heavy duty cutting on rough steel forgings, castings and armor plate. It is used to take the first cut off irregular forgings and has highest strength for interrupted cuts. General recommendations are: depth of cut, 0.060 to 1.250 in.; feed per rev., 0.030 to 0.125 in.; speed, 60 to 125 ft. per min.
For further information circle #1220 on literature request card on p. 32B

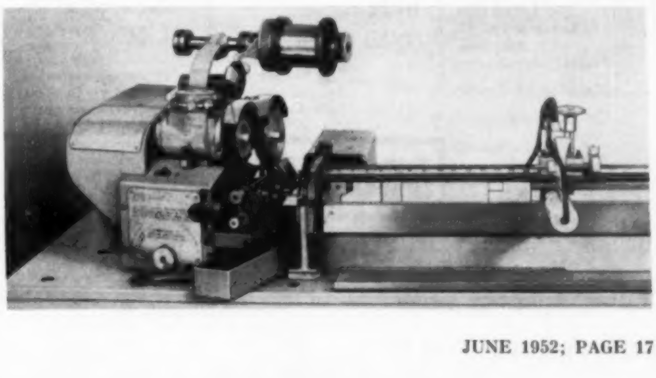
INDUCTION HEATING: A new electronic high-frequency heating unit for soldering, brazing, hardening, annealing and other controlled heat applications has been developed by the Lewis Machine Co. It is designed for use with either ferrous or nonferrous metals. Weighing 350 lb. and costing approximately 5¢ per hr. to operate,



the unit is controlled by an automatic timer switch which may be pre-set from 0 to 60 sec. Output is 1500 watts into a standard NEMA load; frequency, 400,000 cycles; supply, 220-volts, 60-cycle, single-phase. The unit is cooled both by water and a filtered air blower system.
For further information circle #1222 on literature request card on p. 32B

ETCH FOR ALUMINUM: A new compound for the controlled etching of aluminum and its alloys has been

WIRE COILING MACHINE: Driver-Harris Co. has developed a resistance-wire coiling machine to overcome the difficulties hitherto experienced in the production of coils for heater elements of electrically heated appliances and to assure fast, uniform, accurate coiling without damage to the wire. The new coiler *(a)* handles the full range of resistance wire coiling normally required, close or open winding (and can be adapted for twin wire coiling); *(b)* produces coils that stretch absolutely evenly; *(c)* cuts coil ends clean on all sizes, close or open wound; *(d)* maintains resistance accuracy of cut coils at all times by photoelectric control; and *(e)* affords low operational and maintenance costs in addition.
For further information circle #1221 on literature request card on p. 32B



we won our first letter in tool steel

We all remember with pride our first triumphs. Ours was with tool steel. And after a half-century, Crucible is still the nation's top producer.

Therefore, we are keeping our research and development right in step with industry's progress. We are making our experience available to you, with freely offered metallurgical advice. And we provide quick delivery from a fully-stocked warehouse located near *you*.

SEND TODAY for the unique Crucible Tool Steel Selector—a twist of the dial gives the tool steel for your application.

Rex® High Speed Steels
Peerless Hot Work Steels
Holcomb 218
Chro-Mow®
Sanderson Carbon Tool Steels
Ketos®
AirKool Die Steel
Airdi® 150
Nu-Die V Die Casting Steel
CSM 2 Mold Steel
La Belle® Silicon #2
Atha Pneu

SPECIFY YOUR TOOL STEELS BY THESE BRAND NAMES

Crucible Steel Company of America
Dept. MP, Chrysler Building, New York 17, N. Y.

Name__________

Company__________ Title__________

Address__________ City__________ State__________

9" diameter, 3-colors

CRUCIBLE first name in special purpose steels

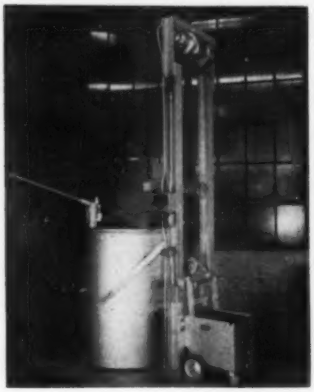
52 years of *Fine* steelmaking

TOOL STEELS

CRUCIBLE STEEL COMPANY OF AMERICA · TOOL STEEL SALES · SYRACUSE, N. Y.

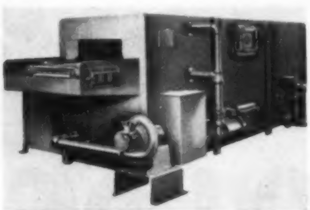
developed by the Silver Star Chemical Corp. Star etch eliminates foaming, sludging, and hard scale formation. Production of a uniform controlled etch is possible either by dipping or mechanical spraying. The bath is easy to operate and maintain.
For further information circle #1223 on literature request card on p. 32B

METAL MELTING: The C. M. Kemp Manufacturing Co. now has available a fully automatic metal loader for speeding up all types of metal melting. A detachable cart raises the load of metal, dumps it and returns



to loading position. Adaptable for any make of melting pot, it is planned as standard equipment for Kemp's complete line of immersion melting pots.
For further information circle #1224 on literature request card on p. 32B

CLEANING: A washing machine designed especially for removing sand mechanically from steel foundry flasks has been announced by the Alvey-Ferguson Co. The flasks pass along on a bar-type conveyor through consecutive high-pressure, fan-shaped



curtains of cleaning solution from above, below and both sides until the flask is free from sand. The cleaning solution, in recirculating through the machine, flows very slowly through a settling tank (not shown in cut) so that the sand settles out of the solution before it reaches the screen tank which screens out foreign particles that might clog the spray nozzles.
For further information circle #1225 on literature request card on p. 32B

MAGNETIC TESTER: Stainless steel and Inconel used on aircraft engine exhaust systems are of very low magnetic permeability when first installed. However, corrosion and crystal-structure changes caused by the excessive heat of the exhaust gases increase the magnetic permeability. The Magne-Probe of American Instrument Co., Inc., is a sensitive and stable bridge which measures the inductance of a coil whose core is the structure being tested. The inductance of the coil is proportional to the permeability of the core material and, therefore, a measure of the heat-corrosion of the structure tested. The instrument is equally useful in testing the soundness of welds. It consists of a probe (about the size of a watch) and an indicating meter (2 x 3 x 4½ in.) connected by a 5-ft. flexible cable. Specialized probes for particular applications are in design. The meter is fitted with a 6-ft. line cord with attachment plug for con-

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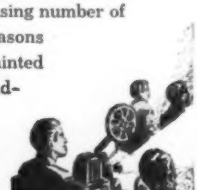

******Instructors in technical schools are also invited to take advantage of these educational aids.*

REYNOLDS METALS

REYNOLDS

necting to a suitable a-c. power source.

For further information circle #1226 on literature request card on p. 32B

CLEANLINESS TESTER: One troublesome factor in the welding of aluminum sheet is the cleanliness of the sheets as presented to the welding head. The surface electrical resistance, in microhms, is a measure of

the effectiveness of the oxide removal or cleaning process employed. The new Model 151-S microhm meter, by J. W. Dice Co., can readily measure the total surface resistance of two sheets or coupons placed between two dummy electrodes. It can accurately measure a resistance as low as one millionth of an ohm (0.000001 ohm), and readings are virtually instantaneous. The linear instrument scale is 0 to 75 microhms. If it is necessary to read higher resistance values, a selector switch cuts in various multipliers which permit taking measurements up to 750,000 microhms.

For further information circle #1227 on literature request card on p. 32B

ALUMINUM TINTING PASTE: Greater two-tone flash for polychrome or metallic finishes is possible through the use of a new aluminum paste made by Aluminum Co. of America. Designated as Aluminum Tinting Paste No. 222, it gives a brighter finish than has been possible thus far with other aluminum pigments. It does not interfere with true color values, and gives an appearance of great depth to the finish. This pigment, while achieving the utmost in iridescence, is characterized by an absence of seeding. Primarily intended for automotive finishes, the new paste also imparts a striking, beautiful effect to the hammertone finish on household equipment and appliances. The metal content of the paste is 65%, and the specific gravity is 1.47.

For further information circle #1228 on literature request card on p. 32B

What's new

IN MANUFACTURERS' LITERATURE

1229. Air-Gas Mixer
Engineering and application data on series "LP" air-gas proportional mixer is available in Bulletin L-300. *Eclipse Fuel Engineering Co.*

1230. Alloy Selection
New 24-page booklet, "Long-Wearing Machinery Parts", contains more than 60 blueprints, tables, and photographs showing some of the sizes and shapes in which cast and wrought parts made from the company's alloys are being used. *Haynes Stellite Co.*

1231. Alloy Steel
8-page booklet on new triple-alloy steel. Hardenability, temperability, properties of treated bars, uses. *The Carpenter Steel Co.*

1232. Alloy Steel
New 16-page, pocket-size booklet entitled "Republic Alloy Steels and How to Get the Most Out of Them" contains seven case histories selected from widely varied fields to demonstrate the versatility of alloy steels. *Republic Steel Corp.*

1233. Alloys
28-page bulletin describes alloys available including ferro-alloys containing titanium and boron, pure metallic titanium and zirconium, and zirconite. *Titanium Alloys Mfg. Co.*

1234. Aluminum Alloy
10-page booklet gives detailed data on properties, characteristics and applications of aluminum casting alloy (7% magnesium). Charts show effect of time and temperature on properties and frequency distribution curves of properties. *William F. Jobbins, Inc.*

1235. Aluminum Alloys
Selector slide-chart. Upper scale setting at one of 12 alloy compositions gives, on lower scale, the properties and uses of the alloy as sand cast, die cast, permold cast and for four conditions of heat treatment. *U. S. Reduction Co.*

1236. Aluminum Bronze
12-page article, "Welding Iron-Bearing Alpha Aluminum Bronze". Test results of improved aluminum bronze alloy sheet with improved weldability. *Ampco Metal, Inc.*

1237. Aluminum Castings
135-page spiral-bound book describes the aluminum casting alloys, foundry principles and practice, design considerations and heat treatment for castings, and 32 pages of tabular data. *Aluminum Co. of America.*

1238. Aluminum Conservation
8-page booklet on efficient use of available supplies of aluminum and the proper handling of scrap. *The Aluminum Assoc.*

1239. Aluminum Fasteners
8-page booklet on all types of aluminum fasteners. Also accessories and screw machine products. All are illustrated. *Aluminum Co. of America.*

1240. Aluminum Forgings
See review on this page.

1241. Aluminum Melt Flux
Data sheet on four fluxes for degassifying and purifying aluminum and aluminum alloys. *Atlantic Chemicals & Metals Co.*

1242. Aluminum Welding
New control system that extends electrode life for spot welding aluminum, fully described in "Technical Advisor No. 15". *Reynolds Metals Co.*

1243. Ammonia
8-page article on applications of dissociated ammonia in powder metallurgy, heat treating, furnace brazing, welding and descaling. *Armour & Co.*

1247. Anti-Carburizing Paint
Descriptive literature is available on paint which prevents carburizing or hardening of certain spots on steel parts. *Case Hardening Service Co.*

1248. Atmosphere Furnaces
Information available on mechanized batch-type controlled atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration work. *Dow Furnace Co.*

1249. Atmospheres
Bulletin 1-10 supplies technical information on inert gas generators and data on reducing inert gas costs. *C. M. Kemp Mfg. Co.*

1250. Atmospheres
Bulletin SC-155 on prepared atmospheres for all heat treating requirements. *Surface Combustion Corp.*

1240. Aluminum Forgings

Designers, engineers, draftsmen — in fact anyone concerned with specifying parts and components — will find a wealth of handy reference data on aluminum forgings in the compact 170-page book, "Designing for Alcoa Forgings".★ It covers in readable fashion such features as typical applications, production techniques, significant design rules for maximum economy and quality, tolerances, machining allowances, drafting conventions, alloy selection and metallurgy. The text is supplemented by 162 illustrations, charts and drawings, plus 16 tabulations of pertinent data.

Aluminum forgings have found their widest acceptance in the aircraft industry, but in recent years have moved into hundreds of other fields. In respect to design of individual parts, full information is presented on draft, parting lines, fillets, corners, webs, ribs, holes and pockets, together with recommended rules for economy in production and quality of parts. The importance of designing forgings so that the fibrous metal "grain" is lined up parallel to the most severe stress and shock loads is emphasized.

One section of the handbook is devoted to the metallurgy of aluminum and how to select the best alloy for specific purposes. Included here is a tabulation of minimum specification values and typical mechanical properties of nine wrought aluminum alloys, as well as their preferred heat treatments.

The concluding chapter reviews applications, production, design requirements and surface treatment of forgeable magnesium alloys, and an appendix contains a glossary of 72 common forging terms.

★Published by the Aluminum Co. of America. Copies are available at no charge to readers of Metal Progress who circle No. 1240 on literature request card, page 32B, and give their company address.

1244. Analytical Balances
Pamphlet on analytical balance having automatic indication of end result by projection of enlarged image of true micrometer scale. *Sartorius Div.*

1245. Annealing
Booklet on burner especially designed for annealing furnaces and other uses where flame impingement is not permissible. *Bloom Engineering Co., Inc.*

1246. Annealing Furnaces
8-page illustrated booklet on continuous annealing furnaces. Schematic diagrams, photographs, and actual production data. *The Drever Co.*

1251. Austempering
Article on modified austempering of cylinder liners at Jacobs Aircraft Co., from current issue of "Tips & Trends". *Ajax Electric Co.*

1252. Barrel Finishing
22-page booklet J-7 gives up-to-date facts and figures on barrel finishing, tells how single-unit installation may yield savings up to 95% on various types of parts. *Almco Div.*

1253. Barrel Finishing
55-page book on barrel finishing with Alundum tumbling abrasive. Procedures, practical operating suggestions, characteristics of abrasive. *Norton Co.*

1254. Beryllium Copper
Helpful engineering information contained in new monthly series of beryllium copper technical bulletins. *Beryllium Corp.*

1255. Bimetal Elements
64-page catalog written especially to help the design and product engineer select the type and size of thermostatic bimetal element best suited to his temperature-responsive device. *W. M. Chace Co.*

1256. Black Oxide Finish
Four-page article "Low-Cost Black Oxide Finish Produced on Steel by Chemical Dip Method". *Mitchell-Bradford Chemical Co.*

1257. Blowers
Bulletin No. 300-S illustrates, diagrams and informs concerning a new constant pressure turbo blower and properly selected piping. *North American Manufacturing Co.*

1258. Brazing
Bulletin 20 tells of advantages of Easy-Flo silver brazing alloy. 24-page bulletin gives information about joint design and fast production methods. *Handy & Harman.*

1259. Brazing
50-page text GEA-3193 describes the methods and applications of electric-furnace brazing. *General Electric Co.*

1260. Brazing
16-page manual gives data for brazing shapes, sheet, castings, tubing and assemblies of copper, brass, steel, aluminum and cast iron. *All-State Welding Alloys Co.*

1261. Brazing Alloys
New 8-page illustrated booklet explains uses of phos-copper and phos-silver extruded alloys for torch brazing, furnace brazing and resistance brazing of copper, brass and bronze. Also data on flux for ferrous and nonferrous metals. *Westinghouse Electric Corp.*

1262. Brazing Washers
Free sample of silver brazing alloy preformed washer coined from wire. *Lucas-Milhaupt Engineering Co.*

1263. Bronze Castings
28-page brochure "Bronze and Copper Bearings and Castings". Analysis, properties and SAE, ASTM, Navy and Federal specification designations of bearing alloys. Cast bars. Properties of eight types of Babbitt. Illustrated description of company's facilities for research, engineering, inspection, casting and finishing. Product applications. *National Bearing Div.*

1264. Bronzes
Folder gives tables of properties (hardness, tensile, fabrication, physical) as well as uses and forms and other data on Chase phosphor bronzes. *Chase Brass & Copper Co.*

1265. Burners
Bulletin on combination gas and oil burner featuring high rate of combustion. *Ra-Diant Heat Refractories Sales Co.*

1266. Burners
Full details of high thermal release burner, unit intended for use where quick heating and intense concentration of heat are desired. *Bloom Engineering Co., Inc.*

1267. Camera Microscope
6-page illustrated folder describes a truly universal and compact metallograph with built-in camera. *Wm. J. Hacker & Co., Inc.*

1268. Carbon Analysis
Bulletin 319 describes the Combustron, electronic induction heater in two or one-tube model for flexibility in analysis of low to high carbon content in alloy steel, cast iron and stainless steel. *Burrell Corp.*

1269. Carburizing
Data folder on Aerocarb E and W water-soluble compounds for liquid carburizing. Case depth vs. time curves. Per cent carbon and nitrogen penetration curves. *American Cyanamid Co.*

1270. Castings, Heat Resistant
4-page bulletin describes heat resistant castings produced in designs for a wide variety of applications, including conveyors, roller hearths, trays, and radiation tube assemblies. *Standard Alloy Co.*

1271. Castings, Nickel Alloy Steel
32-page bulletin with over 100 illustrations reports on steel, cast to shape, as a reliable engineering material. Data on properties and applications of cast nickel steels are classified by industrial fields. *International Nickel Company, Inc.*

1272. Castings, Nonferrous
Booklet available on sand and centrifugal bronze castings. *American Non-Gran Bronze Co.*

1273. Cemented Carbide
16-page catalog of carbide blanks, inserts and tools, with five pages of technical data on applications. *Newcomer Products, Inc.*

1274. Chromium Stainless Steels
Folder gives applications of various chromium stainless steels. Includes table of analyses and properties. *Lebanon Steel Foundry.*

1275. Cleaner
Technical data sheet on AM aluminum cleaner to remove drawing, stamping, spinning compounds, rolling oils, marking inks and crayons as well as general shop dirt. *Cowles Chemical Co.*

1276. Cleaner
Product information folder gives data on industrial metal cleaners for use with water in either still tank or spray washing equipment. *Solventol Chemical Products, Inc.*

1277. Cleaning
New booklet entitled "Your Metal Rearmament Products" contains outline of most efficient methods of handling, as well as cleaning, metal products for defense. *Alvey-Ferguson Co.*

1278. Cleaning
Bulletin 214 gives full details, specifications and actual performance on faster blast cleaning with Rotoblast barrels. *Pangborn Corp.*

1279. Cleaning
Six-page Bulletin 121 discusses 28 difficult cleaning jobs where company's chemicals were successfully applied. *Kelite Products, Inc.*

1280. Cleaning
Six-page bulletin includes concentrations for various metal cleaning applications and a handy list of cleaners for general industrial use. *E. F. Houghton & Co.*

1281. Cleaning
Catalog 152 describes uses and proper selection of shot and grit for impact cleaning and shot peening. *Cleveland Metal Abrasive Co.*

1282. Cleaning Aluminum
Technical data sheet on one-step operation for producing a surface on aluminum that insures consistently good welding. *Nielco Laboratories.*

1283. Cleaning and Finishing
Attractive 12-page, well-illustrated catalog A-652 gives the complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines operating in large metalworking plants. *R. C. Mahon Co.*

1284. Cleaning Machine
Batch cleaning machine is described and illustrated in Bulletin 703AL. *Magnus Chemical Co.*

1285. Coatings
Information on Bonderite, nonmetallic coating which is resistant to corrosion and a good paint base. *Parker Rust Proof Co.*

1286. Cobalt Alloy
12-page booklet, "Haynes Alloy No. 25", tells of the unique properties of cobalt-base alloy. *Haynes Stellite Co.*

1287. Cold Extrusion
Folder describes process in which 5-in. dia. steel billet can be cold formed to a cup with less than ⅛ in. wall thickness in three strikes. *Detrex Corp.*

1288. Cold Finished Bars
12-page booklet describes how cold finished bars may eliminate heat treating, case carburizing, or grinding, minimize warpage, increase machining rates. Properties, applications and fabrication, including selective flame and induction hardening. *LaSalle Steel Co.*

1289. Combustion Control
20-page booklet presents combustion charts for various fuels and describes portable instrument which measures content of oxygen and combustibles simultaneously and continuously. *Cities Service Oil Co.*

1290. Continuous Casting
12-page catalog describes properties, sizes and weights of continuous cast bronzes. *American Smelting & Refining Co.*

1291. Controllers
32-page bulletin, with 114 illustrations and diagrams, describes the eight basic types of M40 Controller. Specifications and method of selecting proper control action included. *Foxboro Co.*

1292. Coolant System
Bulletin describes new atomizing system to aid cooling and lubricating of cutting tools. *Henry G. Thompson & Son Co.*

1293. Copper Alloys
New 44-page booklet on application and installation of condenser and heat exchanger tubes, also plates for tube sheets, heads and baffles. *The American Brass Co.*

1294. Copper Alloys
60-page book of technical information on copper and copper alloys. Six grades of copper and 33 copper alloys are included. *Revere Copper and Brass, Inc.*

1295. Crucible Furnace
Four-page folder gives drawings and specifications of twin crucible furnace for melting nonferrous metals. Also comparison of production data for single vs. twin crucible melting of red brass. *Morrison Industries, Inc.*

1296. Cut-Off Wheels
6-page folder gives data, operating suggestions and grade recommendations of cut-off wheels for delta machines. *Manhattan Rubber Div.*

1297. Cutting Oil
32-page bulletin of case histories on use of all-purpose base in machining operations. *E. F. Houghton & Co.*

1298. Cutting Oil
80 pages of factual data on more than 50 typical metalworking jobs are presented in new edition of "Cutting and Grinding Facts". Also includes descriptions of straight and emulsifiable cutting oils with convenient chart for correct use. *Sun Oil Co.*

1299. Cutting Oil
Shop notebook giving important facts on right cutting fluid for any machining operation. *D. A. Stuart Oil Co.*

1300. Cutting Oil System
Illustrated booklet gives data and charts on new cutting oil, dispensing jet and motor driven pump. Contains test results of overhead flood with conventional coolants vs. new twin development. *Gulf Oil Corp.*

1301. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. Treating cycle, chemistry of bath, raw materials and equipment design. *E. I. du Pont de Nemours.*

1302. Diamond Polishing
4-page folder on advantages of diamond abrasives for polishing metallurgical specimens. Abrasive is offered in three particle sizes. *Buehler, Ltd.*

1303. Die Casting
4-page folder describes four die-casting lubricants developed to provide clean, accurate castings, longer die life and more economical production. *E. F. Houghton & Co.*

1304. Die-Casting Machines
Illustrated booklet giving specifications, application data and full explanations of two new production advantages on company's line of die-casting machines. *Lake Erie Engineering Corp.*

1305. Die Steel
Booklet, "Die Steels for Hot Work", helps in selection of best grade for your particular job. *Vanadium-Alloys Steel Co.*

1306. Die Steel
Literature on Bethlehem cold-headed die steel for high production in forging bolts, rivets, screws, and other products at high speed. *Bethlehem Steel Co.*

1307. Drawing Compounds
Folder describes new type of lubricant for cold forming and drawing of stainless steel, both austenitic and ferritic. *Hangsterfer's Laboratories, Inc.*

1308. Drum Cleaning
6-page, two-color brochure on fast, low-cost drum cleaning. Illustrated. *Pangborn Corp.*

1309. Electric Furnaces
Bulletin No. 473 describes rocking, automatic melting machine for various ferrous and nonferrous alloys. *Detroit Electric Furnace Div.*

1310. Electrodes, Welding
16-page brochure, Bulletin AR51-1, "Alloy Welding Electrodes for Defense Production", describes electrodes for armor, high-temperature alloys, high-strength steels and special applications. *Alloy Rods Co.*

1311. Electron Microscope
New 20-page brochure describes in detail ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA Victor Div., Radio Corp. of America.*

1312. Electronic Equipment
24-page book includes electron microscopes, electron diffraction apparatus, vacuum systems, metal detectors, induction heating and other industrial electronic equipment. *Radio Corp. of America.*

1313. Ferro-Alloys
"Electromet Products and Service" gives helpful information about the use of ferro-vanadium and other alloying metals. *Electro Metallurgical Co.*

1314. Finishes
Four-page folder about Iridite gives the characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research Products.*

1315. Finishes for Aluminum
8-page reprint on surface preparation, application and use of electrochemical, organic, ceramic, mechanical and chemical finishes for aluminum and aluminum alloys. *Aluminum Co. of America.*

1316. Finishing Equipment
12-page catalog of ovens, spray booths and washers for metal finishing. *Burdett Mfg. Co.*

1317. Finishing Systems
Illustrated Bulletin No. 501 on complete finishing systems, metal cleaning and rust proofing equipment, spray booths and baking and drying ovens. *Peters Dalton, Inc.*

1318. Flow Meters
Catalog C-12 gives complete line of meters and accessories for measuring pressure, vacuum and differential pressure of liquids and gases. *Meriam Instrument Co.*

1319. Forging Steel
Bulletin 31 furnishes helpful information on stainless forging problems and includes specific data on chemical composition of alloy steels. *Timken Roller Bearing Co.*

1320. Forgings
Eight-page bulletin on heavy steel and alloy forgings. Applications. Company's facilities. *Titusville Forge Div.*

1321. Forgings
Catalog 51 contains 30 pages covering such topics as type of forgings; where and how to use forgings; turnbuckle dimensions, strengths and related data. Well illustrated with tables and drawings. *Merrill Bros. Co.*

1322. Formed Parts
20-page brochure describes company's facilities for fabricating components from metal wire, strip and other materials. Precision blanking, drawing, forming, wire drawing and welding. *Parts Div., Sylvania Electric Products.*

1323. Forming
Special bulletin of metal spinning, stamping and fabricating facilities. *C. A. Dahlin Co.*

1324. Foundry Ceramics
Bulletin 522 on foundry ceramics that withstand heat shock. Applications to strainer cores, cut-off cores, gate tubes and precision cores. *American Lava Corp.*

1325. Foundry Coatings
Illustrated brochure has information concerning foundry practices as related to the use of colloidal graphite in mold washes, pattern coatings, core coatings, chill coatings. *Acheson Colloids Corp.*

1326. Foundry Mechanization
36-page book No. 2439 gives case histories, foundry layout drawings, installation photographs of ferrous and nonferrous foundries. *Link-Belt Co.*

1327. Furnace Maintenance
A "Maintenance Guide for Electric Heat Treating Furnaces" describes preventive maintenance program for electric furnace users. *Hevi Duty Electric.*

1328. Furnaces
Bulletin HD-850 describes new shaker hearth furnace used for bright carburizing, bright dry cyaniding or bright hardening of small parts in processing up to 150 lbs. per hour. *Hevi Duty Electric Co.*

1329. Furnaces
New all-purpose furnace described in bulletin HD-646 may be used for carburizing, nitriding, dry cyaniding, bright annealing and clean hardening. *Hevi Duty Electric Co.*

1330. Furnaces
12-page bulletin describes chain belt conveyor furnace, radiant tube gas heated, oil or electrically heated. *The Electric Furnace Co.*

1331. Furnaces
Descriptive bulletin on furnaces for annealing, normalizing, hardening, tempering and forging. *Flinn & Dreffein Engineering Co.*

1332. Furnaces
Illustrated bulletin available with complete description of new controlled atmosphere furnace. *Industrial Heating Equipment Co.*

1333. Furnaces
40-page booklet, B-5459, "Harnessing Heat", describes twelve different types of gas and electric furnaces and their applications. Also, a section on the four basic types of protective atmospheres and a glossary of heat treating terms. *Westinghouse Electric Corp.*

1334. Furnaces
Four-page bulletin SC-156 on direct-fired production heat treating furnaces. *Surface Combustion Corp.*

1335. Furnaces
Bulletin 435 describes new furnaces for tool room, experimental or small batch production. Gas, oil, electric. Muffle or direct heated. *W. S. Rockwell.*

1336. Furnaces
Folder describes and illustrates tubular furnace for use in tensile testing, control panels. *Marshall Products Co.*

1337. Furnaces
16-page booklet "Proven Heat Treating Efficiency" containing attractive four-color illustrations displays complete line of furnaces. *Loftus Engineering Corp.*

1338. Furnaces
Complete catalog available describing high-speed gas furnaces designed primarily for heat treating high carbon and alloy steels and also atmospheric pot hardening furnaces for salt, cyanide and lead hardening. *Charles A. Hones, Inc.*

1339. Furnaces
Bulletin describes 18 electric furnaces for research and small-scale production, with top operating temperatures between 2120 and 3000° F. *Harper Electric Furnace Corp.*

1340. Furnaces
44-page Catalog 112, well illustrated, features furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating. Atmosphere generators and ammonia dissociators. *C. I. Hayes, Inc.*

1341. Furnaces, Annealing
Folder of performance and cost data on radiant tube and roller hearth furnaces for heat treating. *The Gas Machinery Co.*

1342. Furnaces, Atmosphere
Bulletin F-1 gives full description of versatile, controlled-atmosphere furnace for all steels from high carbon to high speed in range 1200 to 2800° F. *Delaware Tool Steel Corp.*

1343. Gages
Bulletin BG-MP describes highly accurate beta radiation gage used for thickness measurements. One model measures thickness of material accessible from one side only. *Tracerlab, Inc.*

1344. Galvanometer
Spotlight galvanometer for shop and laboratory work is described in Bulletin 320. *Rubicon Co.*

1345. Gear Hardening
Folder on application of induction heating to high-production hardening of gears. *Westinghouse Electric Corp.*

1346. Graphitic Tool Steels
48-page data booklet contains heat treating data, properties and 46 specific applications of four types of graphitic tool steel. *Timken Roller Bearing Co.*

1347. Grinding Titanium
Article on grinding wheels and techniques for titanium, from "Grits and Grinds". *Norton Co.*

1348. Hard Chrome Plating
Bulletin 1C-250 describes new industrial chromium plating unit and applications to twist drills, taps, extrusion die, files. *Ward Leonard Electric Co.*

1349. Hardfacing
New wall chart which details the proper hardfacing rod for the job. *American Manganese Steel Div.*

1350. Hardfacing
New 40-page booklet "Haynes Alloys —Hard-Facing Manual" tells what metals can be hardfaced, how to select right hardfacing material, lists step-by-step application procedures and industrial applications. *Haynes Stellite.*

1351. Hardness Tester
Four-page bulletin on Brinell hardness tester weighing 26 lb. for portable and stationary use. *Andrew King.*

1352. Hardness Tester
Bulletin DH-114 contains full information on Tukon hardness testers for use in research and industrial testing of metallic and nonmetallic materials. *Wilson Mechanical Instrument Co.*

1353. Hardness Tester
Bulletin F-1689-1 tells of the Impressor, hardness tester for aluminum, copper, brass, bronze and plastics. *Barber-Colman Co.*

1354. Hardness Tester
Literature available on Brinell testing machines. *Detroit Testing Machine Co.*

1355. Hardness Tester
Illustrated circular describes portable hardness tester in sizes for work 1 in. to 6 in. round and flat. *Ames Precision Machine Works.*

1356. Heat Treating
Catalog 116 contains 72 pages of factual heat treating data for carburizing, cyanide hardening, brazing, austempering, and annealing processes. *Ajax Electric Co.*

1357. Heat Treating
Data Sheet lists complete line of heat treat services available at plant. *Vincent Steel Process Co.*

1358. Heat Treating
Booklet describes complete diversified facilities for steel, aluminum and magnesium heat treating. *Pearson Industrial Steel Treating Co.*

1359. Heat Treating
40-page booklet on facilities for tool heat treat, bright hardening of stainless, case hardening, machine quenching, cleaning, straightening and inspection. *Commercial Steel Treating Corp.*

1360. Heat Treating
Handy, vest-pocket data book has 72 pages of charts, tables, diagrams and factual data on late steel specifications, heat treatments, etc. *Sunbeam Industrial Furnace Div.*

1361. Heat Treating
Bulletin 120 tells how Niagara Aero heat exchangers provide better heat control in quenching bath, thus protecting physical properties and saving on water and piping equipment. *Niagara Blower Co.*

1362. Heat Treating
Ipsenlab periodic sheets show case histories on bright hardening, annealing and carburizing. *Ipsen Industries, Inc.*

1363. Heat Treating Baskets
Baskets designed for your individual needs in handling parts. All types of trays, fixtures, retorts and carburizing boxes are described in catalog 16. *Stanwood Corp.*

1364. Heat Treating Fixtures
New catalog No. B-8 contains descriptions and photographs of 75 custom-built fabricated alloy heat treating accessories. *Rolock, Inc.*

1365. Heat Treating Fixtures
Information on complete line of standard carburizing carriers that will handle odd-shaped parts of every type through carburizing and quenching to finishing. *Pressed Steel Co.*

1366. Heat Treating Furnaces
Performance charts on fuel fired or electric heat treating furnaces for hardening, tempering, annealing, normalizing, stress relieving and aluminum treating. Furnace design incorporates both convection and radiant methods of heating. *Standard American Engineering Co.*

1367. Heat Treating Pots
New bulletin T-205 lists 118 patterns available in Thermalloy heat treating pots, both round and rectangular, X-rayed and pressure tested for sound, economical service. *Electro-Alloys Div.*

1368. Heat Treatment
Four-page article, "Precision Heat Treatment of High-Stress Aircraft Parts", describes operations at McDonnell Aircraft Corp. *Sunbeam Corp.*

1369. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes available. *Globar Div., Carborundum Co.*

1370. Heating Equipment
16-page brochure contains reference information and table of steps in selecting industrial heating equipment. *Jensen Specialties, Inc.*

1371. Heating Units
48-page Catalog 50 on Chromalox electric heating units, melting pots, tank immersion heaters, and thermostats. Graphical data on heat losses. *Edwin L. Wiegand Co.*

1372. High Speed Photography
Folder tells how high speed camera and photography can be used to study difficulties in steelmaking. *Eastman Kodak Co.*

1373. High Speed Steel
Technical data folder on "6-6-2" type of tungsten-molybdenum high speed steel. Heat treatments and uses. *Firth Sterling, Inc.*

1374. High-Temperature Alloys
"Thermalloy 30" gives property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

1375. High-Temperature Alloys
High temperature work sheet provides valuable information and suggestions for solving high temperature problems in design and production. *International Nickel Co.*

1376. High-Temperature Steels
87-page spiral-bound book discusses behavior of steels at elevated temperature, factors affecting high-temperature properties. 45 pages of tabular and graphical data on tensile, creep and rupture properties of 21 high-temperature steels. *United States Steel Co.*

1377. Identifying Metals and Alloys
Booklet of procedures for rapid identification of more than 125 metals and alloys. *International Nickel Co., Inc.*

1378. Identifying Stainless Steel
Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel Co.*

1379. Impregnating Castings
Folder on six step impregnation process to eliminate porosity in castings. Includes data on impregnating material. *American Metaseal Corp.*

1380. Induction Heating
Catalog MP-4 describes portable high frequency induction heating unit for brazing, hardening, soldering, annealing and melting. *Lepel High Frequency Labs., Inc.*

1381. Induction Heating
New 12-page, two-color bulletin on equipment for induction heating. Describes components and requirements for hardening, brazing, and annealing at 1000, 3000, and 10,000 cycles. *General Electric Co.*

1382. Induction Heating
Bulletin 1440 furnishes full details on the "Checklite" system for safety control through the use of oversized components built into every unit for longer service life and uninterrupted production. *Lindberg Engineering Co.*

1383. Induction Heating
New 60-page catalog, "TOCCO Induction Heating", tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft Co.*

1384. Induction Heating
"Induction Heating . . . the machine tool that makes tall stories come true" presents case histories of how induction heating has increased production, reduced space and cut costs. *Westinghouse Electric Corp.*

1385. Induction Heating
Bulletin "Induction Heating and Melting" contains the well-known Selector Chart and table giving heating and melting speeds for standard induction equipment. *Ajax Electrothermic Corp.*

1386. Induction Melting
8-page illustrated article describes use of induction melting in improved technique for rotor-casting. *Ajax Engineering Corp.*

1387. Industrial Planning
New book 127 tells how you can share in a "round-table" discussion of planning expansion, remodeling or modernization of your plant. *Continental Industrial Engineers, Inc.*

1388. Inert Gas Welding
Heliwelding, Airco's inert, gas-shielded arc-welding process for all-position welding of aluminum, magnesium, stainless steel, brass and copper, is fully described in ADC-709, Heliwelding. *Air Reduction Sales Co.*

1389. Infared Heating
Ten advantages of far-infrared heat for degreasing, weld preheat, paint baking, heating metal molds, foundry and other applications. *Edwin L. Wiegand Co.*

1390. Instruments
New, 28-page catalog No. 5000 describes the principal instruments, control devices and related components manufactured by the company. *Minneapolis-Honeywell Regulator Co.*

1391. Instruments
Capacitrols and capacilines are described in bulletins PC-1 and CL-1. *Wheelco Instruments Co.*

1392. Iron-Nickel Alloys
32-page bulletin with over 20 tables and charts on austenitic iron-nickel alloys having special thermal expansion or thermoelastic characteristics. *International Nickel Co., Inc.*

1393. Laboratory Furnaces
Series of data sheets give full information on complete line of laboratory furnaces for numerous metallurgical operations. *Boder Scientific Co.*

1394. Laboratory Safety
40-page booklet includes recently developed data, techniques and equipment, and provides useful manual for setting up complete laboratory safety programs. *Fisher Scientific Co.*

1395. Lead-Clad Metals
22-page booklet on the use of lead-clad steel and lead-clad copper in corrosive environments, especially sulphuric acid. *Knapp Mills, Inc.*

1396. Lubricant
8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *The Alpha Corp.*

1397. Lubricant
New, 40-page booklet on Moly-sulfide, solid film lubricant, records experience with 154 different applications. *Climax Molybdenum Co.*

1398. Lubricant, Metalworking
Uses of colloidal graphite for hot metalworking operations (deep piercing, casting, forging, stretch-forming and wire drawing operations) are explained in bulletin No. 426-10F. *Acheson Colloids Co.*

1399. Machining Copper Alloys
32-page booklet suggests cutting speeds, feeds tool rakes and clearances for more than 40 copper alloys. *American Brass Co.*

1400. Magnesium
42-page booklet on processing and properties of wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping Corp.*

1401. Magnesium
Bulletin showing applications of magnesium in modern aircraft, from B36 to S55 helicopter. *Dow Chemical Co.*

1402. Magnesium Melting
Bulletin describes use of fabricated Amera-Mag steel crucibles in melting of magnesium alloys. *American Tank & Fabricating Co.*

1403. Magnesium Welding
Reprint describes an investigation to evaluate inert-gas-shielded metal-arc welding of magnesium. *Air Reduction Sales Co.*

1404. Manganese Bronze
Article discusses effects of lead and tin on mechanical properties of manganese bronze and effects of arsenic, antimony, phosphorus, lead and tin on dezincification. *R. Lavin & Sons, Inc.*

1405. Mechanical Cleaning
New 76-page catalog No. 210 simplifies selection of power brush for the individual job; contains numerous colored illustrations of various types of brushes in operation. *Osborn Mfg. Co.*

1406. Mechanical Tubing
Bulletin TB 339 on manufacture of machined parts with tubing. Tabular data on carbon steel tubing. *Babcock & Wilcox Co.*

1407. Melting Furnaces
24-page book on electric furnaces for steel mills and foundries. Many photographs of furnaces in action. Table of types, sizes, ratings. *American Bridge.*

1408. Melting Nonferrous Metal
Bulletin MP223 describes oil or gas fired, tilting furnaces for rapid melting of nonferrous metals. *Johnston Mfg.*

1409. Metal Conveyor Belt
28-page Catalog No. 4 on metal belts for use in acid alkali baths for heat treating furnaces and other applications. *Cyclone Fence Div.*

1410. Metal Conveyor Belts
44-page illustrated catalog describes metal belts for quenching, tempering, annealing, hardening, brazing, carburizing, powder metallurgy and other applications. *Ashworth Bros., Inc.*

1411. Metal Spraying
Article "Metallizing — What It Is, What It Does", in current issue of "The Metallizer". *Metallizing Co. of America.*

1412. Metallograph
Revision of catalog includes the new metallograph with polarizing and phase attachments. *American Optical Co.*

1413. Metallographic Polishing
Booklet on two-speed polishers. Units are for flush or table mounting and in single, double or triple unit tables. *Buehler Ltd.*

1414. Micrographic Equipment
6-page bulletin on a universal camera microscope giving plate magnifications from 4 to 3000 ×. Full details on optics and accessories. *Opplem Co.*

1415. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Kent Cliff Laboratories.*

1416. Microphotometers
12-page bulletin on comparator microphotometers, recording and nonrecording. Specifications, drawings, detailed description. *Jarrell-Ash Co.*

1417. Microscopes
Well-illustrated 22-page catalog describes new line of laboratory microscopes featuring ball bearings and rollers throughout the focusing system and a low position fine adjustment, providing comfortable operation for high precision work. *Bausch & Lomb.*

1418. Nondestructive Testing
Data available on electronic inspection equipment, demagnetizers and comparators for sorting. *Magnetic Analysis Corp.*

1419. Nondestructive Testing
Series of bulletins gives data on both ultrasonic and magnetic nondestructive testing instruments. Illustrated. *J. W. Dice Co.*

1420. Oil Quenching
16-page catalog V-1146 describes self-contained oil cooling equipment. Detailed solutions to typical problems. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett Co.*

1421. Oven Furnaces
Bulletin No. 200 describes Model 231 gas furnace. *American Gas Furnace.*

1422. Ovens
Bulletin 14-T showing applications of ovens for low temperature heat treating of ferrous and nonferrous metals illustrates and describes batch and conveyor-type ovens with operating temperatures up to 1000° F. *Young Bros. Co.*

1423. Phosphor Copper
20-page book on how to use phosphor copper as a deoxidizer and hardener for bronze and brass alloys in foundries and rolling mills and for the making of phosphor bronzes, brazing metal and other alloys. *Ajax Metal Div.*

1424. Plating Barrels
4-page folder illustrates and describes equipment designed to handle any barrel plating problem quickly and easily with a unique contact arrangement for maximum current distribution. *Daniels Plating Barrel & Supply Co.*

1425. Plating Generators
Catalog MP-700 describes M-G set for electroplating, anodizing, electrocleaning, or electropolishing in either large or small-scale operations. *Columbia Electric Co.*

1426. Plating Racks
8-page, illustrated booklet offers data on a plating rack designed to make the spline section or body of the plating rack a permanent tool. *National Rack Co., Inc.*

1427. Polishing and Buffing
Bulletin entitled "Acme Straightline Automatic Polishing and Buffing Machines" illustrates and describes a machine for every type of polishing and buffing job. *Acme Mfg. Co.*

1428. Potentiometer, Portable
Bulletins 270 and 270-A describe portable potentiometers in a selection of ranges up to 1.6 volts. *Rubicon Co.*

1429. Pots
Bulletin N-1 tells of pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Fuel Engineering Co.*

1430. Powder Metal Parts
Bulletin shows 20 powder metal parts with statement of material, method used previously and cost reduction through use of powder metallurgy. *Wel-Met Co.*

1431. Precision Casting
12-page, illustrated booklet on precision casting with emphasis on the most widely used equipment and supplies. Check list of applications in various fields. *Alexander Saunders & Co.*

1432. Precision Castings
12-page booklet, "High-Quality Precision Castings for Industry", describes company's plaster mold casting process. *Atlantic Casting & Engineering Corp.*

1433. Pre-Coated Metal
4-page folder and sample of metal strip pre-finished with a coating that will withstand stresses of drawing, bending and forming without cracking or peeling. *Coated Coil Corp.*

1434. Properties of Steel
140-page book of tensile and hardness properties of carbon and alloy steel after various conditions of heat treatment and for sections up to 35 in. *Heppenstall Co.*

1435. Protection for Aluminum
Folder describes application and results of Brush Alodine for protection of painted or unpainted aluminum. *American Chemical Paint Co.*

1436. Protective Chemicals
Quick reference list of rust proofing, paint-bonding and metal protective chemicals is intended for all fabricators of steel, zinc and aluminum products. *American Chemical Paint Co.*

1437. Pyrometer
Pyro immersion pyrometer for nonferrous foundries is described in Bulletin 150. *Pyrometer Instrument Co.*

1438. Pyrometer Equipment
A new Buyer's Guide for pyrometer supplies, No. 100-4, is ready for distribution. *Minneapolis-Honeywell Regulator Co.*

1439. Pyrometer Wires
Chart of color codes, calibration symbols, thermo elements of thermocouple and extension wires for ISA, U. S. Military and Aeronautical specifications. *Thermo Electric Co., Inc.*

1440. Pyrometers
New circular gives complete information on Xactemp pyrometers. New Type LT-840 and all accessories are illustrated and described. Xactline straight-line temperature control for use with any standard pyrometer controller is described in a companion folder. *Claud S. Gordon Co.*

1441. Quenching Additive
8-page brochure tells in detail how carbon steel often replaces alloy steel when additive is used in quenching oil. *Aldridge Industrial Oils, Inc.*

1442. Quenching Oil
14-page brochure giving results of comparative tests of various quenching mediums in regard to center cooling curves, distortion, uniformity of surface hardness, and depth of hardening. *Gulf Oil Corp.*

1443. Quenching Oil
8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil Co.*

1444. Radiography
34-page book, "Industrial Applications of the X-Ray", features radiography of castings and weldments. *General Electric X-Ray Corp.*

1445. Radiography
Bulletin 400-310 on self-contained X-ray unit for mass production inspection of parts. *Westinghouse Electric Corp.*

1446. Recirculating Furnaces
16-page Bulletin 81 describes and illustrates heat treating furnaces for ferrous and nonferrous parts and other heat treat equipment. *Despatch Oven.*

1447. Refractories
New 12-page illustrated brochure presents products for casting special refractory shapes and products for gunning and slap troweling applications, for services through 3000° F. *Johns-Manville.*

1448. Refractories
Revised bulletin entitled "Lumnite Refractory Concrete" discusses latest available information on refractories and heat-resistant concrete. *Lumnite Div., Universal Atlas Cement Co.*

1449. Refractories
20-page booklet gives technical information of a basic nature on super refractories. Contains text, charts, tables, illustrations and application data. *Carborundum Co., Refractories Div.*

1450. Refractory Mixes
Well-illustrated 16-page bulletin No. 315 provides important data on properties and applications of Sillimanite super-refractory ramming mixes and patches. *Chas. Taylor Sons Co.*

1451. Rhodium Plating
Directions for rhodium plating, with particular reference to its use as replacement for the usual plating metals. *Baker & Co., Inc.*

1452. Roll Temperatures
Bulletin 405 describes new measuring head for recording and controlling roll surface temperatures. *Foxboro Co.*

1453. Rotary Straightener
Catalog describes two-roll rotary straightener for round tubes and bars 1/16 to 3/16 in. O.D. *The Medart Co.*

1454. Rust Proofing
6-page bulletin on phosphate coating process that protects iron and steel from corrosion. *Detrex Corp.*

1455. Salt Baths
Technical Bulletin No. H-1 describes Neutra-Gas Process, for maintaining neutrality in chloride-base salt baths. *Park Chemical Co.*

1456. Salt Baths
32-page bulletin, "Liquid Salt Baths", discusses heat treating salts for tempering, annealing, neutral hardening, martempering and carburizing. Heat treating data. *E. F. Houghton & Co.*

1457. Salt Baths
28-page booklet, "Salt Bath Heat Treatment", deals with heat treatment, carburizing, maintenance of baths, safety precautions. Six time-temperature-case depth curves included. *American Cyanamid Co.*

1458. Salt Spray Test Cabinets
Illustrated bulletin describing test cabinet conforming to Spec. QQ-M-151a for corrosion testing in salt-fog or humidity-laden atmosphere. *Industrial Filter & Pump Mfg. Co.*

1459. Sawing Refractories
Illustrated folder describing use of masonry saw for shaping refractory bricks. Pictures of nine different shapes and number of seconds required to cut each shape. *Clipper Manufacturing Co.*

1460. Saws
Catalog 49 describes complete line of metal-cutting saws, covering 35 models in ten basic types, including fast, automatic production saw, hydraulic hacksaws and widely used small shop saws. *Armstrong-Blum Mfg. Co.*

1461. Silver Brazing
48-page, pocket-size manual on all aspects of silver brazing applications and problems. *The American Platinum Works.*

1462. Soldering Equipment
8-page brochure on soldering and brazing equipment describes new Mogul soldering gun and shows its applications to production-line soldering and brazing. *Metallizing Co. of America.*

1463. Solvent Cleaning
24-page brochure describes medium-pH cleaner for use following solvent degreasing or other precleaner. Other products included in brochure also. *Northwest Chemical Co.*

1464. Spectrographs
A 52-page guide to spectrographic apparatus for metallurgical and general chemical analysis. *Jarrell-Ash Co.*

1465. Spectrophotometer
Bulletin B-211 illustrates junior-size spectrophotometer for identifying and measuring solution constituents in analytical or production laboratories. *Harshaw Scientific Div.*

1466. Spring Steel
Handbook describes various spring steels and gives tolerance tables, heat treatment and physical property tables and fabrication data. *A. R. Purdy Co.*

1467. Springs
Information on compression, torsion, flat, extension and special springs. *John Evans Sons, Inc.*

1468. Stainless Castings
28-page full-color industrial fantasy, "Alloys in Cooperland", captures the spirit of Lewis Carroll in describing how stainless steel castings are made. *The Cooper Alloy Foundry Co.*

1469. Stainless Fabrication
133-page, attractively bound book, "Fabrication of U. S. S. Stainless and Heat Resisting Steels", covers welding, riveting, soldering, joint design, machining, cutting, forming, annealing, pickling, surface finishing and protection of stainless steels. 20 pages of tabular data. *U. S. Steel Co.*

1470. Stainless Steel
Properties and composition of precipitation hardenable stainless castings (16 Cr, 4 Ni, 4 Cu). *Cooper Alloy Foundry Co.*

1471. Stainless Steel
12-page book, "Type 430 Stainless Steels as Alternates of the 18-8 Series". Fabrication data, four pages of comparative corrosion ratings for Types 430, 302 and 316. *Republic Steel Corp.*

1472. Stainless Steel
Weekly lists with analyses of all plates in stock and latest data. *G. O. Carlson, Inc.*

1473. Stainless Steel
Slide chart. Set top at a certain fabricating operation, bottom shows rating of each standard grade. On reverse side, heat treating and corrosion data are given for each grade. *Carpenter Steel Co.*

1474. Steel, Aircraft
62-page "Aircraft Steels" booklet includes revised military specifications to August 1951. Also sizes and analyses of aircraft steels carried in stock. *Joseph T. Ryerson & Son, Inc.*

1475. Straightening Wire
Bulletin 52-AA describes straightening machine for wire in size range from 1/16 to 1 in. diameter, at speeds up to 200 ft. per min. *The Medart Co.*

1476. Stress Analysis
Revised edition of "Photoelastic Stress Analysis" shows the engineer why this method is effective for solving problems of stress distribution. *Eastman Kodak Co.*

1477. Stress-Relieving
New 4-page catalog folder describes how many unnecessary cleaning operations can be eliminated by new, practical, steam Homo method for stress-relieving of small brass parts. *Leeds & Northrup Co.*

1478. Subzero Freezer
4-page folder on portable freezer, 110-volt a.c., operating to −180° F., for shrink fitting, hardening, stabilizing and testing. *Webber Appliance Co.*

1479. Surface Roughness
4-page folder with description, s fications, illustrations of portable face comparator for point-of-pro tion examination of surface finis range 1 to 100 micro-in. rms. *E Meters, Inc.*

1480. Tank Heaters
6-page bulletin describing imme heater for plating tanks, cleaning, ishing and quenching tanks. *I Hold Mfg. Co.*

1481. Temperature Control
36-page Bulletin P1245 gives info tion on new electronic instrument recording and indicating a wide va of variables. Includes charts and ing diagrams, many photographs. *Bristol Co.*

1482. Testing Equipment
New 80-page illustrated catalog testing and measuring equipment laboratory and production line Photos, diagrams, descriptions of 130 pieces of testing and measu equipment. *General Electric Co.*

1483. Testing Machines
New 30-page catalog on screw p universal testing machines and a sories includes illustrations and d of construction and specifications. information on special tools for d ent tests. *American Machine & M*

1484. Testing Machines
Universal testing machines equipment are diagrammed, desc and illustrated in 20-page Bulleti *Tinius Olsen Testing Machine Co.*

1485. Testing Machine
New universal testing machin 12,000 lb. capacity is presented in trated Bulletin 336. *Baldwin-L Hamilton Corp.*

1486. Thermocouple Data
42 pages of data and charts cov all types of control accessories. *Wh Instruments Co.*

1487. Thermocouples
Catalog H gives complete descri of thermocouples, quick coupling nectors, panels, pyrometers, exte wires and accessories. *Thermo El Co.*

1488. Thermocouples and I rometer Accessories
56-page book comprising a U Manual, illustrated Buyers' Guide specifications and prices and the couple calibration data. *The Brist*

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1489. Titanium and Zirconium
16-page bulletin, "The Hydrimet Process", describes titanium and zirconium metal and hydride, and other metallurgical hydrides. *Metal Hydrides, Inc.*

1490. Tool Steel Color Guide
Color guide to estimate the temperatures of heated steels has heat colors on one side and temper colors on the other side. *Bethlehem Steel Co.*

1491. Tool Steel Selector
Twist the dial of the 9-in. circular selector and you can read off the tool-steel for your application. *Crucible Steel Co. of America.*

1492. Tool Steels
Full information on uses, compositions and heat treatment of carbon and carbon-vanadium tool steels. *Vanadium-Alloys Steel Co.*

1493. Tool Steels
8-page booklet describes seven tool steels for machining and die work, with particular emphasis on applications in the fastener industry. *Universal-Cyclops Steel Corp.*

1494. Tool Steels
Stock list of available tool and die steels. *Reliable Steel Co.*

1495. Tubes, Bars, Steel
New stock list on 52100 tubing and bars as well as ring forgings. *Peterson Steels, Inc.*

1496. Tubing
Catalog No. 20 describes complete line of small tubing, giving analyses and sizes. *Superior Tube Co.*

1497. Tubing
10-page current stock list of alloy and stainless steel tubing and pipe. *Babcock & Wilcox Co.*

1498. Tubing Failures
Factors affecting tube life in high-pressure, high-temperature applications are presented in 40-page booklet which is the result of a great number of investigations of failures. *Babcock & Wilcox Co.*

1499. Tubing Machine
4-page folder, "Machine Hot-Forms Tubing into Complex Parts", treats the economic advantages of hot-forming in the same plant where the precision-sized tubing is produced. *Tube Reducing Corp.*

1500. Ultrasonic Testing
Commercial services using reflectoscope and reflectogage are described in bulletin 50-105. *Sperry Products, Inc.*

1501. Vacuum Metallurgy
Bulletin entitled "National Research Corp. and Vacuum Metallurgy" gives brief résumé of the vacuum metallurgical operations and background of this company and of the research and development facilities and services available to the metallurgist. *National Research Corp.*

1502. Vacuum Supplies
40-page illustrated catalog 11 K listing research high-vacuum equipment, pumps, oils, gages and supplies. *Research Vacuum Supply Co.*

1503. Vanadium Recovery
Six-page article, "Recovery of Vanadium and Other Alloys in the Acid Electric Furnace", from Vancoram Review. Extensive tabular data. *Vanadium Corp. of America.*

1504. Vapor Degreaser
Vapor degreaser described and diagrammed in folder. Data on different models. *Topper Equipment Co.*

1505. Weld-Through Sealer
Data sheet and sample of sealer that resists heat and pressure of spot welding without splattering and burning. *Minnesota Mining & Mfg. Co.*

1506. Welding
"Improved Design for Welding" describes the economies of good welding design as compared to haphazard design methods. *Linde Air Products Co.*

1507. Welding
16-page booklet describes company's operation, typical weldments and welded rings produced. *American Welding & Manufacturing Co.*

1508. Welding Electrode Chart
New 4-page electrode selector chart lists the proper electrodes to be used in the welding of various metals. *General Electric Co.*

1509. Welding Equipment
Cadweld process and complete list of arc-welding accessories are described in catalog. *Erico Products, Inc.*

1510. Welding Flux
16-page booklet describes use of back-up flux on the underside of welded seam. Application chart for 25 steels and nonferrous metals. *Solar Aircraft.*

1511. Welding Pressure Vessels
Reprint describes procedures for welding stainless, stainless-clad and copper alloy pressure vessels and refinery components. *Air Reduction Sales Co.*

1512. Welding Tool Steel
Technical brochure on use of tool steel electrodes in rebuilding worn or damaged areas of tools and dies. Tempering curves for weld deposits from five types of tool steel electrodes. *Alloy Rods Co.*

1513. Welding With Bronze
Eight-page reprint, "Jobs You Can Do With Bronze Electrodes", describes techniques and choice of bronze electrodes for welding various copper, steel and cast iron subassemblies. *Ampco Metal, Inc.*

1514. Wire
Catalog 100 lists grades, sizes and compositions of standard wires and specialties such as flat wire. *Seneca Wire & Mfg. Co.*

1515. Wire, Nonferrous
4-page folder contains wire gage and footage chart and information on beryllium copper, phosphor bronze, nickel silver, brass and aluminum wire. *Little Falls Alloys, Inc.*

1516. Wire-Coiling Machine
Bulletin C-52 describes machine to coil resistance wire uniformly, rapidly and accurately. *Driver-Harris Co.*

1517. Wire Straightening
Bulletin 52-C describes precision machine for straightening small wire with extreme accuracy. Applies to round wire 0.007 to 0.125 in. diameter of ferrous or nonferrous metal. *Medart Co.*

1518. X-Ray Film
Bulletin containing reference chart on selection and relative speeds of company's industrial X-ray films. Also exposure-density curves. *Ansco.*

1519. X-Ray Supplies
48-page catalog of industrial X-ray supplies and accessories. *General Electric X-Ray Corp.*

1520. Zinc Die Castings
8-page booklet of data on properties, design advantages and uses of "really small" zinc alloy die castings. Chart compares cost, production and design features of various fabricating methods. *Gries Reproducer Corp.*

1521. Zinc Galvanic Anode
40-page booklet, "Zinc as a Galvanic Anode", deals with cathodic protection against corrosion. Numerous tables and charts. *Federated Metals Div.*

1522. Zirconium
New price schedule and data on pure ductile zirconium. *Foote Mineral Co.*

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1226	1252	1278	1304	1330	1356	1382	1408	1434	1460	1486	1512
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1228	1254	1280	1306	1332	1358	1384	1410	1436	1462	1488	1514
1229	1255	1281	1307	1333	1359	1385	1411	1437	1463	1489	1515
1230	1256	1282	1308	1334	1360	1386	1412	1438	1464	1490	1516
1231	1257	1283	1309	1335	1361	1387	1413	1439	1465	1491	1517
1232	1258	1284	1310	1336	1362	1388	1414	1440	1466	1492	1518
1233	1259	1285	1311	1337	1363	1389	1415	1441	1467	1493	1519
1234	1260	1286	1312	1338	1364	1390	1416	1442	1468	1494	1520
1235	1261	1287	1313	1339	1365	1391	1417	1443	1469	1495	1521
1236	1262	1288	1314	1340	1366	1392	1418	1444	1470	1496	1522

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

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Postcard must be mailed prior to Sept. 1, 1952.
Students should write direct to manufacturers.

For Top Production:

IN-LINE X-RAY INSPECTION

For mass inspection of parts, the Westinghouse Productograph offers safe, speedy X-ray examination—easily fits into production lines. Fully ray-proofed, the Productograph requires no specially trained X-ray operator—can be pre-set for mass inspections, or manually controlled for individual checks.

This unit can be used with Westinghouse 150 kv or 250 kv industrial X-ray units. Two 14" x 17" parts trays are carried on dollies through the unit to permit a maximum number of inspections per exposure.

For highest speed in mass X-ray inspections, select the Productograph. Call your Westinghouse representative, or write: Westinghouse Electric Corporation, Dept. P-61, 2519 Wilkens Avenue, Baltimore 3, Maryland.

YOU CAN BE SURE...IF IT'S

Westinghouse

INDUSTRIAL X-RAY

"It's foolish to try to be bigger than you are"

REMEMBER Aesop's fable of the frog and the ox? Told 2,500 years ago, it goes:

"Three young frogs cried to their mother that a little brother had been trampled by the largest beast in the swamp. 'Oh, no,' said the mother, 'no beast is larger than I.' And she blew herself up to show how big she really was. 'But it was much bigger,' the little ones chorused. Whereupon the vain mother inflated herself until she burst." And the moral was, "It's foolish to try to be bigger than you are."

Aside from the wisdom of the fable for each of us individually, there is solemn warning for us as a nation. Some among us seem to believe that with an unlimited supply of taxpayers' dollars America can buy anything--ease and security at home, acceptance of our ideas abroad, friendship of other peoples, even world peace.

Like the vain frog, America inflates herself more and more dangerously, trying to stretch herself to be the biggest thing in the swamp. Meanwhile the enormous beast that is the world goes its own way, scarcely affected by the vainglorious display of America's inflation. It's the same old world that was indifferent before the pomp of Egypt, Persia, Greece and Rome.

How will our present "puffing" end? Isn't it obvious that continued inflation can bring disaster? Only by a realistic policy of living within our means--not trying to be bigger than we are--can America avoid the catastrophe of Aesop's foolish frog.

YOUR SCRAP IS NEEDED — YOUNGSTOWN

The Youngstown Sheet and Tube Company

General Offices--Youngstown 1, Ohio

Export Offices--500 Fifth Avenue, New York

MANUFACTURERS OF CARBON ALLOY AND YOLOY STEELS

The steel industry is using all its resources to produce more steel, but it needs your help and needs it now. Turn in your scrap, through your regular sources, at the earliest possible moment

Customer Reports:

"Considerably Less Waste Metal" with Asarco Continuous-Cast Bronze

Servel, Inc., Evansville, Indiana, manufacturer of electric refrigeration compressors, has found a twofold benefit in its use of Asarco Continuous-Cast Bronze: Improved performance of a production line item because of superior dispersion of constituents in the bronze; a sharp reduction in material cost due to lower reject rate and less short-end scrap.

This Asarco customer uses Continuous-Cast Bronze to fabricate a shaft sealing member which runs against hardened steel with very little lubrication. The constituents of the bronze must be distributed throughout its cross-section *with absolute uniformity* to preclude failure of the seal due to rubbing. Individual casting and chilling of these parts has been given up in favor of Continuous-Cast Bronze.

The unique Asarco casting process gives you bronze rods, tubes and shapes with properties up to 100% better than those of sand-cast bronzes . . . with no porosity, no hard or soft spots. Asarco Continuous-Cast Bronzes are ideal for use on automatic screw machines.

You can get Continuous-Cast Bronzes made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ by special arrangement.

216 sizes of standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths by distributors across the nation . . . in diameters of ½″ to 5″, cored or solid. This bronze will be cut *long or short* to suit your needs.

Free illustrated catalog describing properties, sizes, weights, etc., is available on request. Use coupon below.

These photomicrographs demonstrate the superior dispersion of constituents in continuous-cast alloys . . . also their freedom from porosity and other metal faults. (Alloy of 75% Cu, 5% Sn, 20% Pb shown here).

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RODS TUBES SHAPES ®

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Please send me a free copy of the 12-page catalog "Asarco Continuous-Cast Bronze."

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WHEREVER TOOL STEELS ARE APPLIED...

Why work alone

to get more output from present facilities?

Why work alone... when you can use the experience of *hundreds* of men to help raise tooling standards and get maximum productivity from manpower and equipment?

Here's a personalized program developed *expressly for* the plant that makes or uses tools and dies. It is the net thinking and imagination of many specialists to help you add speed and sureness to the hands of toolmakers and heat treaters. It brings you ideas and methods to shorten tooling-up cycles, break production bottlenecks and train apprentices faster. It's brought right to your plant door by your Carpenter representative.

Consider the many things that make it work: Time-saving data from constant Carpenter laboratory research, issued in regular Service Bulletins. More than 60 years of experience in applying tool steels, made available in Carpenter's Matched Tool and Die Steel Manual. Timely tips on getting more from present heat treating equipment, yours in a new slide chart. Modern, *visual* slide films to refresh skilled men and train apprentices.

Why work *alone* to boost output, when this personalized program is available at no extra cost? Start now to get the help it brings you. THE CARPENTER STEEL COMPANY, 133 W. Bern St., Reading, Pa.

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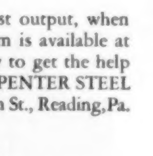
MATCHED TOOL & DIE STEELS

Export Department: Carpenter Steel Co., Reading, Pa.—"CARSTEELCO"

Mill-Branch Warehouses and Distributors in Principal Cities Throughout the U. S. A. and Canada



RAMMED CHROME HEARTH lasted 2 weeks

Pusher type, oil fired furnace. Temperature at entrance end 1000 F; 2400 F at discharge end.

"CARBOFRAX" SKIDS STILL GOOD after 2 years

For 16 hours (sometimes 24 hours) a day, five days a week, forging billets are pushed through this furnace. When it was equipped with a rammed chrome ore hearth, about two weeks of this punishment was all the furnace could take. The hearth would cut out. The furnace would have to come down for repairs.

Then, in December 1949, CARBOFRAX silicon carbide skid rails were installed. The furnace was started up, and exactly one year later, 16,554 tons of billets had been pushed over these skids. And they still looked as good as new.

Four months later, the furnace was down for some rearrangement of the front end. The close-up shows one of the skid rail brick as it appeared at that time — worn down only 1/16"!

Today, those skids are still in service, still in good condition.

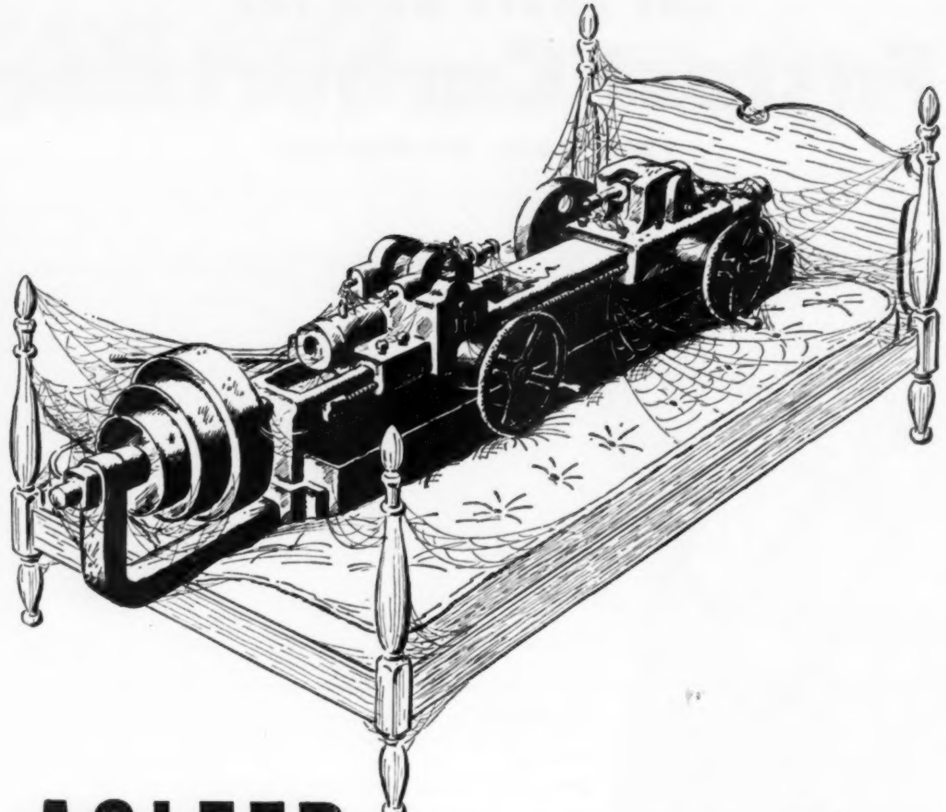
Think what this means in terms of down time, labor, and materials . . . savings you might make, too. Write today for further information. Our address: Dept. C-62, Refractories Div., The Carborundum Co., Perth Amboy, N. J.

Use Super Refractories by

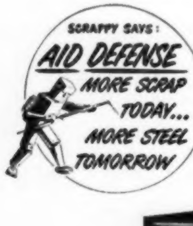
CARBORUNDUM

Trade Mark

"Carborundum" and "Carbofrax" are registered trademarks which indicate manufacture by The Carborundum Company



ASLEEP...on your time



An obsolete or worn-out machine, stuck away, sleeping and forgotten in a corner of your plant, is costly.

It is not doing you or anyone else any good. It is taking up valuable space.

Call in a scrap dealer and let him haul away your dormant scrap. It will help to supply the tons of additional scrap that is needed if the country's steel furnaces are going to continue working at full capacity.

Today there are millions of tons of dormant scrap hidden away in plants and factories, and on farms.

If the steel mills can get that scrap, the steel supply picture will be very much brighter, with more steel for everybody. Call in a scrap dealer today!

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

More Scrap Today... More Steel Tomorrow

and chose the
BRISTOL DYNAMASTER
Continuous-balancing electronic recorder

The instrument makers whose advertisements appear above know that their reputations depend upon the accuracy and reliability of their recorders. They select each component part with scrupulous care.

As the recording unit in their instruments, they all selected Bristol's Dynamaster. When you choose the Dynamaster for your own measuring needs you are assured of the same accurate, precise instrumentation demanded by these instrument makers.

THERE'S A DYNAMASTER FOR EVERY NEED

Available as a bridge or potentiometer, with strip or circular charts, Dynamasters can measure any variable that can be converted into changes in d-c voltage, d-c current, resistance, or capacitance.

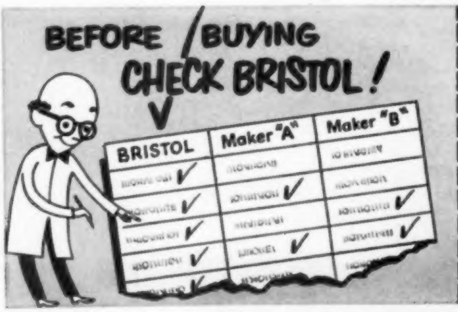
Dynamasters are providing accurate, trouble-free measurement and automatic control of such quantities as temperature, pressure, pH, speed, voltage, power, current, smoke density, strain, and resistance.

BRISTOL

FOR MORE INFORMATION *on the uses of this versatile recorder, use the coupon to get Catalog No. P1245.*

The dependable Guidepost of Industry

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



THE BRISTOL COMPANY
106 Bristol Road
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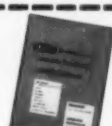
Please send catalog giving details of Dynamaster performance to:



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COMPANY ______________

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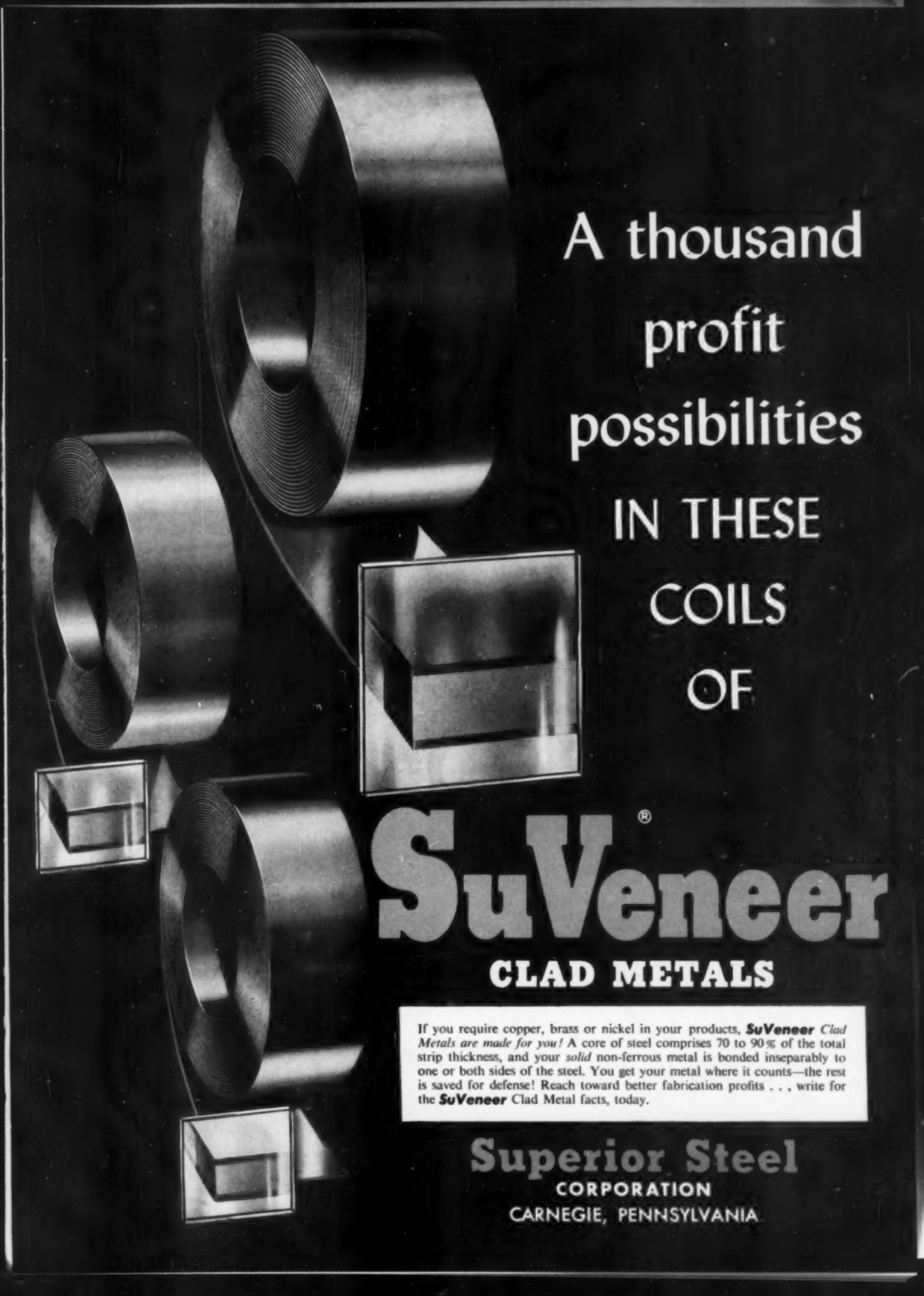
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possibilities
IN THESE
COILS
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If you require copper, brass or nickel in your products, **SuVeneer** *Clad Metals are made for you!* A core of steel comprises 70 to 90% of the total strip thickness, and your *solid* non-ferrous metal is bonded inseparably to one or both sides of the steel. You get your metal where it counts—the rest is saved for defense! Reach toward better fabrication profits . . . write for the **SuVeneer** Clad Metal facts, today.
Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

2 ways to ease your Steel Shortage

1 Collect all dormant Steel Scrap and get it to the steel producers

Millions of tons of valuable scrap still lie idle in America. Scrap salvage means more production—a stronger America. Clean out your plant . . . sell all your iron and steel scrap to your local scrap dealer now. The need is urgent. Every bit will help to meet the needs of defense production.

KEEP IT MOVING
SCRAP STEEL
TO YOUR SCRAP DEALER

2 Make your steel supply go farther —specify N-A-X HIGH-TENSILE STEEL

Users of N-A-X HIGH-TENSILE steel find they can make 3 tons do the work of 4. Through its high strength and corrosion-resistant properties, lighter sections can be used without sacrifice of quality. It fabricates and welds with the ease of mild carbon steel. Let us assist you in applying this economy to your products.

MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
N·A·X
HIGH-TENSILE STEEL
... And "MAKE YOUR PRODUCT LAST LONGER"

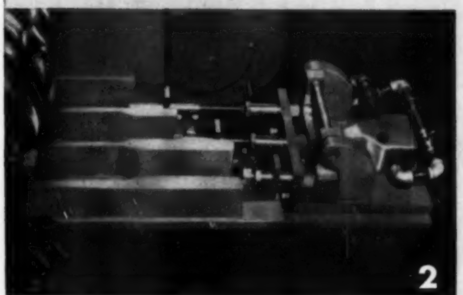
GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division — Ecorse, Detroit 29, Mich.

NATIONAL STEEL CORPORATION

REDUCEROLL
your forging blanks!

1



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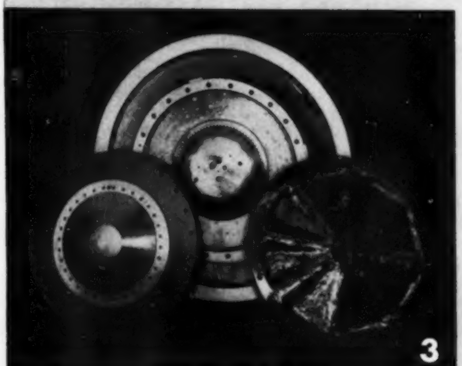


3

THE NATIONAL REDUCEROLL • BUILT IN SIX SIZES

REDUCEROLLING — A revolutionary rolling technique that is proving to be a cost-saving short cut to forging blank preparation — is a forge man's dream come true.

Built into National REDUCEROLLS is the ability to produce greater reductions in area than those previously accomplished by rolling. Machine features include:

- *** ROLL ASSEMBLY (photo No. 1) Ingenious mounting arrangement assures a tight operating fit and quick roll change.**
- *** AUTOMATIC STOCK GAUGE TRIP UNIT (photo No. 2) sets rolls in motion at the instant stock is in place against gauge. Eliminates use of foot treadle, speeds operation, reduces fatigue.**
- **** DIAPHRAGM CLUTCH (photo No. 3) is air-cooled and operates with only a single friction plate. This is the same rugged clutch which is compiling unparalleled performance records on the latest National Forging Machines and MAXIPRESSES.**

Let us help you investigate the application of REDUCEROLLING to your forging work. Send us a print or sample of your forging — better yet, pay us a visit. No obligation.

*Patents Applied for

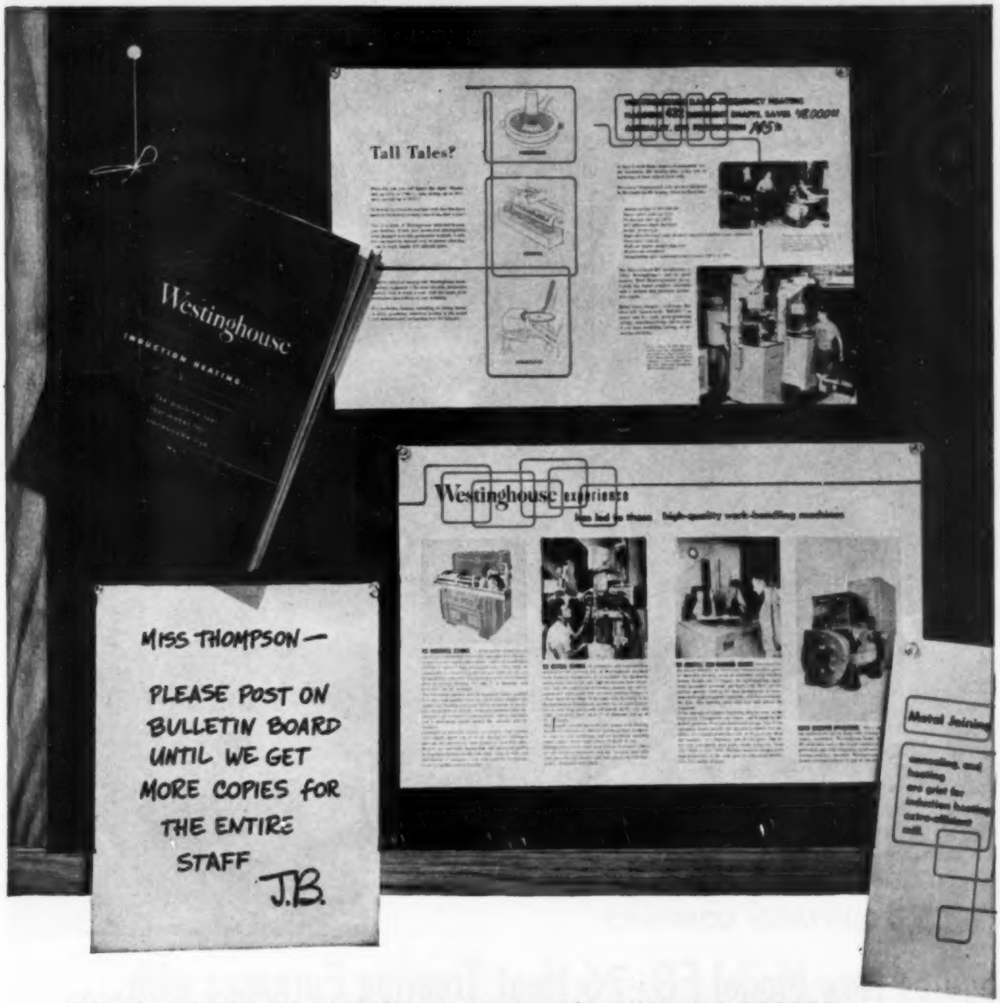
**Patented

NATIONAL
MACHINERY COMPANY

TIFFIN, OHIO—SINCE 1874

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES • MAXIPRESSES • REDUCEROLLS • COLD HEADERS • BOLTMAKERS • NUT FORMERS • TAPPERS • NAILMAKERS

Hartford Detroit Chicago



HERE'S PROOF OF INDUCTION HEATING'S AMAZING RECORD—

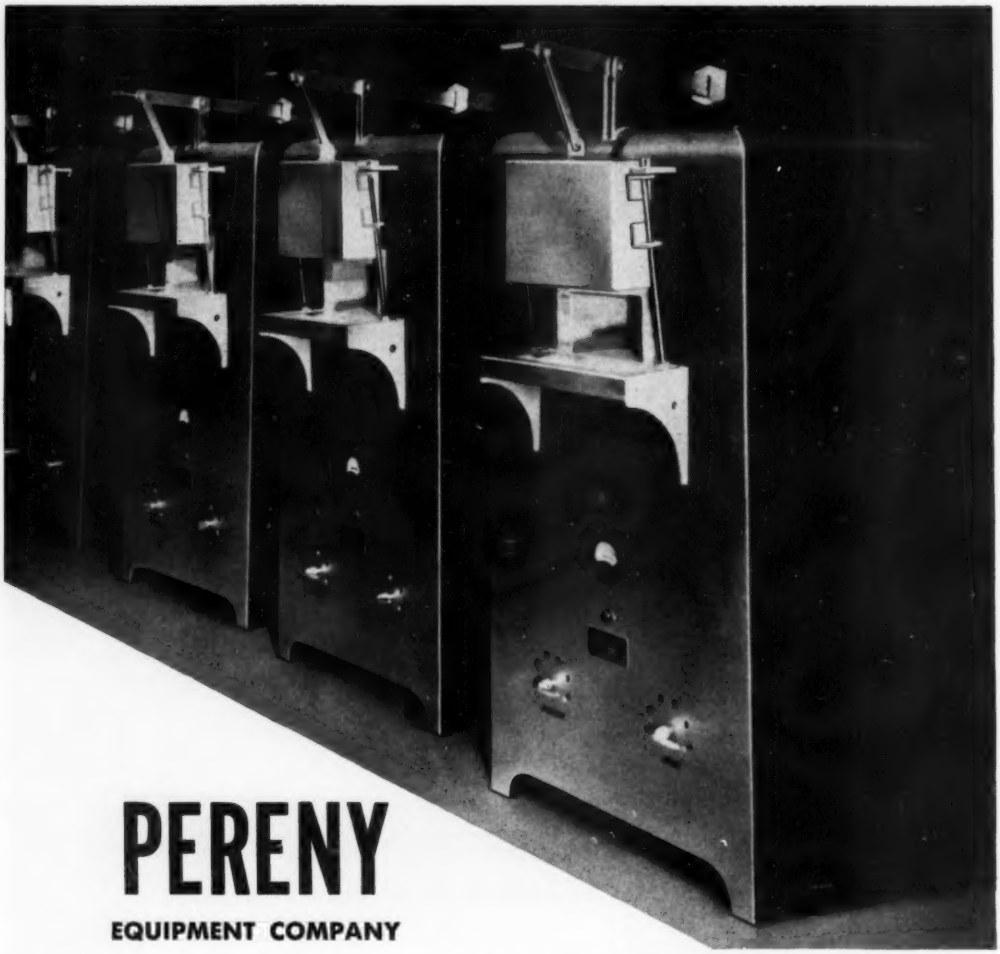
Actual case histories of hardening, brazing, soldering, and annealing installations show how the RF process has meant increased production (as high as 2000%), lower costs (as much as 90%), and a higher quality product for many of America's leading manufacturers. It's an amazing story — with facts and figures released by the companies themselves — and results that speak for themselves. See how these manufacturers' experiences may parallel your own . . . how RF Heating may help achieve production efficiency in *your* plant.

Send for this free booklet today — ask for B-4782. Write Westinghouse Electric Corporation, Department P-35, 2519 Wilkens Avenue, Baltimore 3, Maryland.

Westinghouse

INDUCTION HEATING

J-



PERENY

EQUIPMENT COMPANY

equips New Model FG-76 Heat Treating Furnaces with...

This battery of 24 Pereny Model FG-76 heat treating furnaces was designed and built to meet the rigid requirements and strict specifications of the Air Force. When put into actual operation, performance proved to be exceptional. So excellent, in fact, that this model has now been added to Pereny's standard line of heat treating furnaces.

In this new model, as well as in other Pereny furnaces, GLOBAR silicon carbide heating elements are used, because of the advantages they offer in design, construction, and performance. These furnaces provide extremely flexible temperature range, uniform heating, and safe, clean operating conditions. Long, trouble-free service is realized. Replacement of elements, when required, is a simple procedure, and can be done without interrupting production.

Model FG-76 is 40" deep x 33" wide x 70" high. It has a chamber 8" wide x 16" deep x 6" high. Operating temperature is 2500°F. Complete data may be obtained by writing Pereny Equipment Co., Columbus, Ohio.

For the latest complete data on GLOBAR elements address your inquiry to Dept. MP 87-110, GLOBAR Division, The Carborundum Company, Niagara Falls, New York.

GLOBAR

Heating Elements

by CARBORUNDUM

TRADE MARK

"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company.

87-110

The hole idea is to save you steel
...and machining time!

IF you're a hollow parts manufacturer, here's an idea that will help you save steel and cut production costs, too: Use Timken® seamless steel tubing instead of bar stock!

With Timken seamless tubing, the center hole is already there. There's less scrap loss because there's less metal to be machined away. You get more parts per ton of steel.

Timken seamless tubing also helps make your machine tools more productive. Drilling is eliminated and finish boring is often your first production step. Screw machine stations are released for other operations. You get more machining capacity without adding machines.

You get better quality in your product, too! The piercing process by which Timken seamless tubing is made is basically a forging operation. The tubing has a uniform spiral grain flow for greater strength and a refined grain structure which brings out the best in the quality of the metal. And the Timken Company's rigid quality control insures uniformity from tube to tube and heat to heat.

TUBE ENGINEERING Service. To help you save even *more* steel, the Timken Company offers a tube engineering service which recommends the most economical tube size for your job—guaranteed to clean up.

For further information on the use of Timken seamless tubing, write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

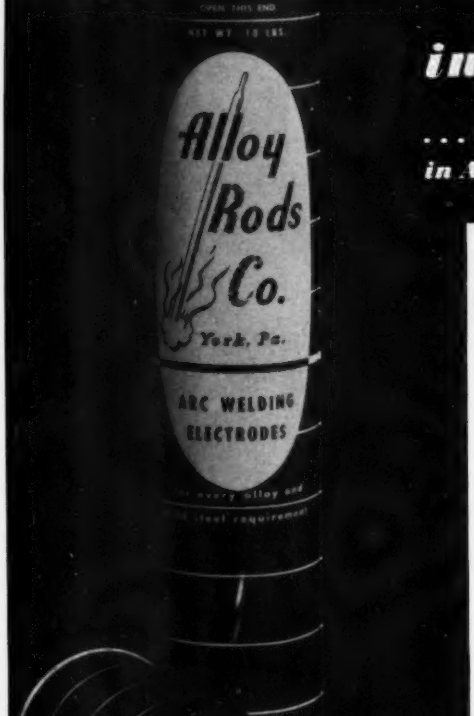
YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

HIDDEN STRENGTH

in trained hands

. . . there's more than meets the eye in Alloy Rods arc welding electrodes



NO WELDING ROD is better than the skill of the welder using it . . . but any skilled welder can get consistent *quality* welds, faster and cheaper, using *Alloy Rods'* seven complete lines.

Principal reasons: *Alloy Rods'* continuous *quality control*—continually producing identical characteristics in each grade of electrode from every production run . . . continuous on-the-line testing and inspection . . . the continuous efficiency and exclusive production techniques of the world's most modern electrode manufacturing plant, *producing arc welding electrodes only.*

Although our Distributors may temporarily be out of stock on certain types, we urge you to keep in touch with them on your requirements. After all, *quality* is always worth waiting for.

NAMES TO REMEMBER IN ARC WELDING

ARCALOY for stainless steel
ARMORARC for armor welding
BRONZE-ARC for bronze and cast iron
NICKEL-ARC for cast iron
TOOL-ARC for tool steel
WEAR-ARC for hard-facing
WELD-ARC for low hydrogen electrodes

***Contact your Alloy Rods Distributor or write for specific product Bulletins.**

AR-4

ALLOY RODS COMPANY

No Finer Electrodes Made . . . Anywhere

YORK, PENNSYLVANIA

The hard, cold facts about Pittsburgh's hot furnaces!

47 PLANTS OKAY THE HEAT PROVER

Pittsburgh's great steel industry needed an instrument to measure air infiltration, to check air requirement and fuel-air ratio controls in open-hearth furnaces . . . an instrument to check the stoves in which blast-furnace air is heated . . . to check precise atmospheres in soaking pits . . . to control fuel waste and precise atmospheres in processing furnaces.

THE CITIES SERVICE HEAT PROVER WAS THE ANSWER . . . and it received the stamp of approval from engineers in 47 different mills in and around Pittsburgh!

Cities Service Heat Provers . . . *not an instrument you buy, but a service we supply* . . . helped to boost furnace productivity through these five unique advantages:

1. Rapid continuous sampling.

2. Simultaneous reading of oxygen and combustibles.

3. Direct measurement of oxygen and combustibles.

4. Easy portability.

5. No maintenance; no re-calibration.

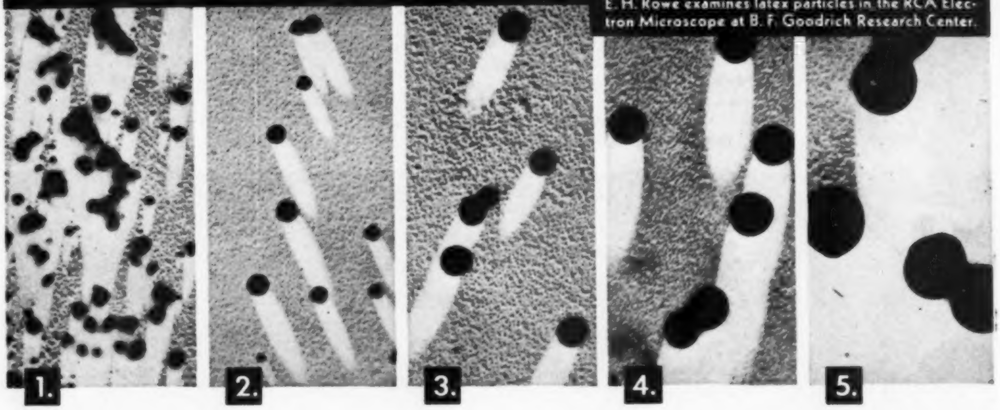
These points begin to tell you why Cities Service Heat Prover analyses are just as much favored in glass, ceramics, steam generation and other fields as in the great Pittsburgh steel area. For the full story as it applies to you, write CITIES SERVICE OIL COMPANY, Dept. F20, Sixty Wall Tower, New York City 5.

CITIES SERVICE

How the RCA electron microscope helps B. F. Goodrich make better latex rubber

E. H. Rowe examines latex particles in the RCA Electron Microscope at B. F. Goodrich Research Center.

These 5 RCA Electron Microscope micrographs (magnified 27,000 X) show the 5 successive polymerizations made by B. F. Goodrich to study effect of emulsifier on latex particles. (Note shadows caused by deposit of uranium.)



PROBLEM: to maintain *just the right amount* of emulsifier in a synthetic polymer latex. Particle size and stability of the latex depend on how much emulsifier is present. *Too much* starts new particles forming. *Too little* causes premature flocculation of the latex.

SOLUTION: Latex particles, shadowed with uranium, were studied in the RCA Electron Microscope. Five polymerizations were made; using the particles in the first for the seed of the second, and so on. From this study, engineers could determine just the right amount of emulsifier. Result: *better* control and *better* product.

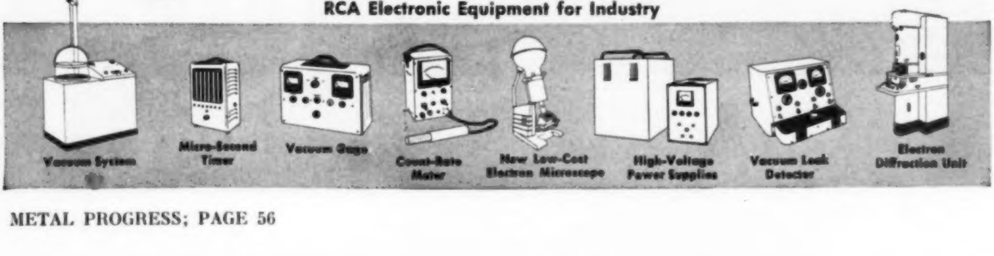
Could YOU use this kind of research help?

Just think what you could do with this powerful RCA research tool in *your* operations. It's from 20 to 50 times more powerful than the best light microscopes . . . gives sharp clear images magnified from 500 to 23,000 diameters, photo enlargements up to 100,000 diameters. Also useful for electron diffraction studies. More information? Write Dept. 72F, RCA Engineering Products Department, Camden, New Jersey.

SCIENTIFIC INSTRUMENTS
RADIO CORPORATION of AMERICA
ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

RCA Electronic Equipment for Industry

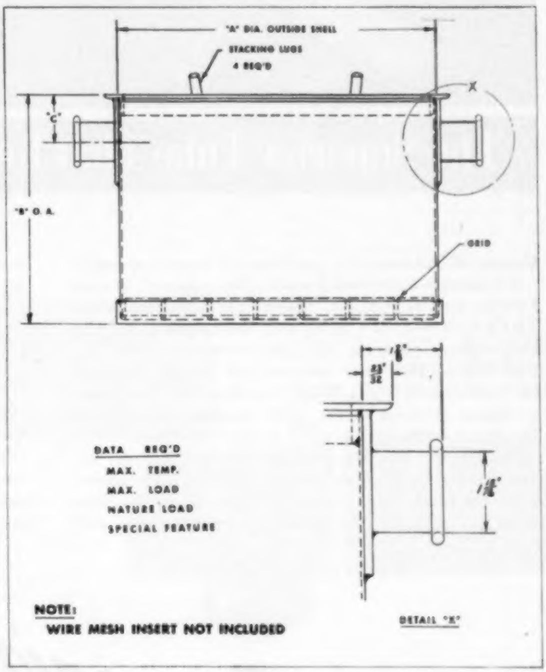


ROLOCK

FABRICATED ALLOYS

A Cost-saving method to inquire for... or order...

PIT TYPE FURNACE STACKING BASKETS



Rolock standardized type, fully fabricated-welded alloy baskets are handled as a group, nesting in a pick-up sling. The principal design feature is in the very high live-dead load ratio... one answer to greater service life.

Usual construction employs a fabricated grid (see drawing) but wire mesh, as shown above, may be used. Assemblies to fit standard or existing vertical furnaces can be supplied to your specifications. Use the drawing for quotes or orders.

SEND FOR FULLY ILLUSTRATED CATALOG

Offices: PHILADELPHIA, CLEVELAND, DETROIT, HOUSTON, INDIANAPOLIS, CHICAGO, ST. LOUIS, LOS ANGELES, MINNEAPOLIS, PITTSBURGH

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

for better work
Easier Operation, Lower Cost

Tool Steel Topics

Our Brake Die Steel Solves Wear and Warp Problems

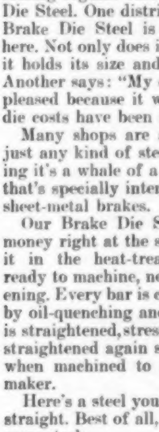
We've never introduced a more popular specialty steel. And there are good reasons why more and more shops are becoming regular customers for our Brake Die Steel. One distributor writes: "Your Brake Die Steel is going over big out here. Not only does it machine easily, but it holds its size and shape beautifully." Another says: "My customers are highly pleased because it wears and wears . . . die costs have been cut in half."

Many shops are accustomed to using just any kind of steel. Now they're finding it's a whale of a saving to use a steel that's specially intended for dies used in sheet-metal brakes.

Our Brake Die Steel saves time and money right at the start because we ship it in the heat-treated condition — it's ready to machine, needs no further hardening. Every bar is carefully heat-treated by oil-quenching and tempering. Then it is straightened, stress-relief-annealed and straightened again so that it won't warp when machined to contour by the die-maker.

Here's a steel you can count on to *stay* straight. Best of all, it far outwears ordinary steels.

We stock Bethlehem Brake Die Steel in standard sizes in our Mill Depot; it's also stocked by many distributors of Bethlehem tool steels. Folder 560 gives full details.



This four-way die is typical of the uses of our Brake Die Steel.

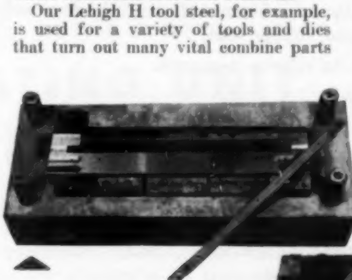
Lehigh H Tool Steel Helps Build Big Grain Combines

This Gleaner-Baldwin self-propelled combine does everything but bake the bread as it cuts a 14-ft swath in a wheat field. It's a one-man operation.

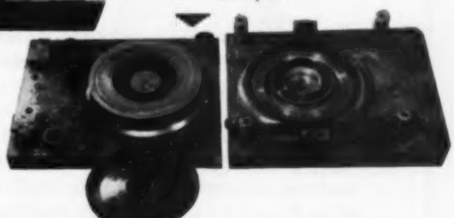
It's easy to see why the modern self-propelled combine makes old-timers blink in admiration and wonder. One such machine made by Gleaner Harvester Corp., Independence, Mo., requires but one man at the controls. It performs a continuous harvesting operation as it cuts a 14-ft swath through vast fields. Cleaned grain pours into a 50-bushel bin in a steady stream. In just 90 seconds the bin can be unloaded while the machine continues on the go.

It takes precision manufacturing to make these mechanical marvels run smoothly and dependably. And that's where Bethlehem tool steel comes in.

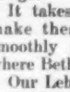
Our Lehigh H tool steel, for example, is used for a variety of tools and dies that turn out many vital combine parts from sheet steel. Gleaner's well-equipped toolmaking division reports complete satisfaction with this fine grade of air-hardening tool steel. Its high-carbon, high-chromium content makes it first choice for high production because of its long-wearing properties. And it has minimum distortion during heat-treatment.



Raddle slats, which convey the crop to the combine separator, are produced from 12-gage sheet steel by this die of Lehigh H tool steel which forms, pierces, and cuts off. Die shown has already produced about 100,000 pieces.



Lehigh H is also used in this blanking, flanging, and dishing die which produces a 17-in.-diameter cylinder head for the threshing mechanism. This die operates in a 400-ton press.



BETHLEHEM TOOL STEEL ENGINEER SAYS:

Use Shock Steels for Shock Tools

When using standard manganese oil-hardening tool steels (such as our BTR grade) for jobs requiring more than average shock-resistance, the usual practice is to temper the tool or die so that the hardness is reduced to about 50 Rockwell C. This is not recommended, because at a given hardness a steel of this type, having a relatively high carbon content, can't match the shock properties of a lower-carbon, shock-resisting steel.

If a tool has to be tempered that far to get the necessary toughness, then probably a shock-resisting steel should be used rather than a general-purpose steel. Omega, our silico-manganese steel, is ideal for all types of cold-battering tools . . . and 67 Chisel, our chrome-tungsten grade, is the steel to use for a wide variety of shock tools and master hobs.

Left: **DESULPHURIZING LADLE** for handling gray iron being lined with a special Norton ALUNDUM* refractory cement.
Right: In operation, ALUNDUM cement lining lasts 2 to 4 times longer than other linings.

Desulphurizing ladle linings last up to 4 times longer

... with Norton ALUNDUM cement

How long do your present ladle linings stand the violent boiling action that results when you add sodium carbonate briquettes to desulphurize your gray iron?

Not long enough? Change to a special Norton ALUNDUM refractory cement and see what happens.

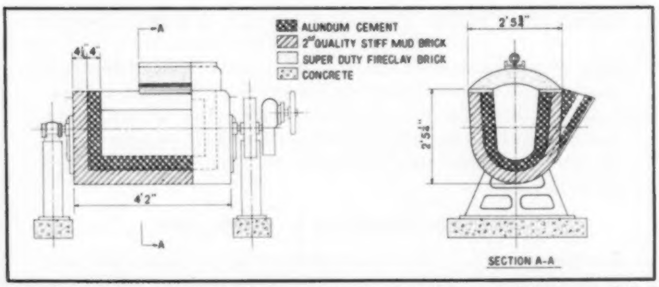
Test Shows Amazing Results

In one case, a foundry which operates a 1500 lb. capacity Whiting "U" shaped ladle for desulphurizing gray iron decided to test ALUNDUM cement. Lining life was increased 200-400%.

This foundry has now standardized on Norton ALUNDUM cement . . . and gets extra dividends in the form of easier installation, lower maintenance cost, lower over-all refractory cost.

Run a Test Yourself

Yes, why don't you test Norton ALUNDUM cement in your ladles, too? In the meanwhile, get further information from your nearby Norton representative — or write direct to Norton Company, Refractories Division, 323 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.



NORTON ALUNDUM CEMENT, in the test mentioned, was air-hammered 4" thick over 4½" of second quality stiff mud brick in the ladle and the entire spout. This was air dried overnight . . . and heated gently with a low-flame gas torch until thoroughly dried. Finally, the ladle was brought up to full heat and put into service.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

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Special REFRACTORIES

Making better products to make other products better

NORTON COMPANY, WORCESTER 6, MASSACHUSETTS

Metal Progress

Vol. 61, No. 6 · June 1952

Technical Articles

Critical Points

Departments

Abstracts of Important Articles

Cold water strikes red hot metal in end-quench hardenability test—first step in Ryerson quality control.

RED HOT REASON for Buying Ryerson Alloys

There is no question about it—our end-quench hardenability tests certainly simplify your job of buying and heat treating today's interim and lean alloys. With the hardenability of your particular steel thus definitely determined, the other mechanical properties can also be predicted—with confidence.

These hardenability tests are but one step in a unique program that makes Ryerson alloys easier to buy and safer to use. Starting with careful selection of every heat carried in Ryerson stock, the plan follows clear through to the certification of analysis and hardenability that is sent with every shipment of as-rolled or annealed Ryerson alloy steel.

Now more than ever this Certified Plan makes Ryerson your best source for alloys. Though defense demands are taxing even our extensive facilities we can undoubtedly take care of most of your requirements. So for quick shipment of pre-tested alloy steels which you can buy and heat treat with confidence, call the nearest Ryerson plant. And remember we also carry heat treated alloys in stock for immediate shipment.

PRINCIPAL PRODUCTS

CARBON STEEL BARS—Hot rolled & cold finished

STRUCTURALS—Channels, angles, beams, etc.

PLATES—Many types including Inland 4-Way Safety Plate

SHEETS—Hot & cold rolled, many types & coatings

TUBING—Seamless & welded, mechanical & boiler tubes

ALLOYS—Hot rolled, cold finished, heat treated

STAINLESS—Allegheny bars plates, sheets, tubes, etc.

TOOL STEEL—Oil and water-hardening types, ground flat stock

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MACHINERY & TOOLS—For metal fabrication

RYERSON STEEL

RYERSON STEELS

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By F. B. Rinck, Engineer, Finishing, Western Electric Co., Indianapolis Plant

Finishing Metal Parts for Telephones

The standard telephone in use throughout the Bell System is built to give dependable service over long periods and under a wide variety of conditions. To build long service into this instrument, great importance is attached to the type and quality of the finishes applied to its various parts. The kind and the amount of finish on any particular part are primarily functional and are governed by whether the part requires protection against corrosion, has to be soldered or welded, or has to make good electrical contact. To satisfy these requirements, 16 types of inorganic finishes and many kinds of organic systems have been adopted.

The decision to build a new plant solely for telephone manufacture, and the location chosen, warranted a restudy of the whole finishing problem, especially in view of the water supply. In a wholly new plant there is an opportunity for engineering an economical and modern line-up of processes, equipment, and layout. The parts manufactured are relatively small, but are produced in sufficient quantities to justify the use of fully automatic platers for zinc, nickel, copper-nickel, and gold, as well as individual barrel plating sections for zinc, copper-tin, nickel, silver, and gold. Control of the processes has thus been transferred to the machine rather than the individual operator — a big advantage in starting a plant in a new location without experienced help.

The automatic platers for zinc and nickel are standard machines modified to accommodate the cleaning cycle used for our type of work. This cycle consists of an anodic caustic cleaner and a hydrochloric acid pickle using an imposed alternating current, plus an anodic cyanide cleaner for the zinc plater. Spray rinses are generally used, and to conserve water, they are synchronized with the movement of the plater so the spray is on only when a rack is in rinsing position.

Undercoats for Enamel — In making the number plate for the dial telephone, the copper-nickel automatic plater is used to coat ordinary cold rolled mild steel so that a white ceramic enamel can be applied in one operation. Since it is a functional finish, the process has been developed to give good enameling results, and the equipment is used only for this purpose. A copper undercoat 0.0004 in. thick seals off the steel, and then 0.0002 in. of nickel is deposited over the copper to prevent discoloration of the enamel. De-ionized water* is used to make up all plating and cleaning solutions; it is also used in the spray rinses before the parts enter the plating baths, and for the final rinse before drying. The chemical cleanliness obtained by such pure rinse water has improved the quality of the enamel finish.

Automatic Gold Plater — Among the parts shown in Fig. 1 which are plated with rare metals are the brass electrodes that come in contact with the carbon granules in the telephone transmitter, coated with approximately 0.00004 in. of gold in an automatic plater. The character of this surface has considerable effect on the quality of the sound transmitted by the set; consequently every effort is made to secure a uniform and adherent coating with a chemically clean surface.

This automatic gold plating machine is arranged in a closed loop and is essentially two platers in one, for nickel underplate and gold overplate, having two loading and unloading positions. The parts are placed in special stainless steel racks (Fig. 2) which are loaded onto the plater at the first position at the end of the loop. They progress successively through the tanks for nitric acid pickling, city water rinse, pure water rinse, nickel plating, and two rinses in city water (Fig. 3). They are then removed from the plater, and transferred from the stainless steel racks to hard rubber racks which mask the portions of the part that do not require gold plating. Since the spacing of the parts in the two racks is the same, the transfer is made by placing one rack above the other and reversing their position.

The loaded rubber racks are placed on

*De-ionized water is free of the carbonates and chlorides of ordinary surface waters, and is purified by the process of ion exchange, to be discussed at length in an article by Bernard Ostrof in the July issue.

Barrel Plating Arrangements

the plater, and carried through the final cleaning, gold plating, and rinsing operations, which include the following tanks in succession: hydrochloric acid dip; pure water rinse (two tanks); gold strike and plate; pure water rinse (three tanks arranged for recovery of drag-out); final pure water rinse; dilute nitric acid dip; pure water rinse and unload.

De-ionized water is used for makeup of all these solutions and for rinsing throughout the gold plating cycle. The amount of gold deposited is controlled by ampere-minute meters. Mechanization of this process has decidedly improved the quality of the product as well as reduced the required thickness of gold to a minimum while still meeting the exacting requirements of telephone parts.

Barrel Plating Sections have been laid out to include integrated cleaning, plating, and drying units for each finish. This has not only reduced the labor required, but has also given better control over the individual processes. Since the zinc barrel section handles the largest volume of work, extra large barrels with inside dimensions 14 x 36 in. are installed. They are made of a high-temperature acrylic resin. The finishing cycle consists of loading the barrel, cleaning the parts in a hot alkali solution, rinsing, pickling in cold hydrochloric acid, rinsing, neutralizing in a sodium cyanide solution, plating in a cyanide zinc bath, rinsing, chromating, and rinsing. The parts are then unloaded directly from the barrel into a centrifuge for final drying.

The current drawn by each barrel in the plating operation is from 800 to 1000 amp. so that nearly 50,000 Btu. per hr. per barrel has to be dissipated to maintain the optimum operating temperature of the plating bath. This is accomplished by circulating the solution through an external heat exchanger cooled by the direct expansion of Freon. The pressures in the refrigerating

Fig. 2 — Operators Are Loading Stainless Racks With Brass Parts to Receive an Undercoating of Nickel Preparatory to Gold Plating in the Same Machine. The surface contacts carbon granules in the transmitter and its quality greatly affects the quality of transmission

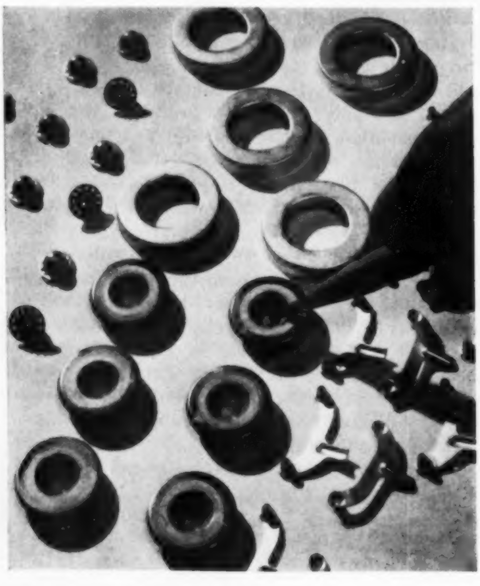


Fig. 1 — Silver and Gold Plate Insures High-Quality Electrical Contact Surfaces in These Parts. The small part at the upper left, commonly called the "derby hat" by operators, contacts the carbon granules in the transmitter as does the inner curved surface of the part pointed out by the pencil. Both parts receive fine coatings of gold. The other two parts are copper-silver plated. The ring at upper right and the odd-shaped part at the lower right are copper-silver plated for contact purposes

system are so regulated that the plating solution is never cooled below room temperature, thus preventing the deposition of carbonates on the cooling surfaces of the heat exchanger.

The anode baskets used in the plating tank were designed to handle commercial slab zinc. The plating time is controlled for each barrel by an ampere-hour meter which is set at the beginning of a load; it lights a signal and rings a bell to indicate the completion of the plating run. The large barrels used for both cleaning and plating have reduced handling time on this job to one quarter that formerly required. Automatic control of the cycle involves considerable equipment; a panel and adjacent tank are shown in Fig. 4, and a general view of a zinc plating line is given in Fig. 5.

Brass terminals and rivets which are to be subsequently soldered are plated in copper-tin barrels. A copper undercoat 0.0002 in. thick is followed by 0.0001 or 0.0002 in. of tin. The copper undercoat increases the length of time that the parts can be stored and still be readily soldered. The parts to be plated are cleaned in baskets in a unit that is an integral part of the process. They are then copper plated, rinsed, tin plated, rinsed, and neutralized — all in the same barrel. Centrifugal drying is the final operation in the cycle. Ampere-hour meters control the plating time.

Cycles Automatically Controlled

The nickel barrel plating section is divided into two units — one for brass parts and the other for steel. No brass parts are plated in nickel solutions which have been used for plating ferrous parts because contaminated solutions may produce a nickel plate lacking the ductility required to withstand later crimping operations during assembly. Most of the nickel plating is functional rather than ornamental, and no bright nickel baths are used. (Elimination of brighteners also gives a very ductile nickel.) Again, the thickness of the nickel deposit is controlled by ampere-hour meters, set at the beginning of a load.

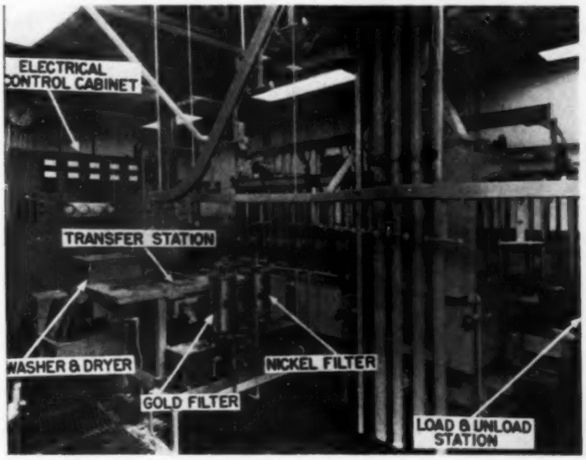
Silver plate is used for contact purposes only. The parts are cleaned and acid-dipped in baskets, after which they are placed in a 14 x 30-in. plating barrel. The cycle consists of copper plating, a silver strike, silver plating and centrifugal drying. De-ionized water is used in the makeup of solutions and the critical rinses. The silver solution is continually filtered, and activated carbon is used periodically to remove organic matter. The weight of deposit is closely controlled by ampere-hour meters.

Gold plating of small parts that can be tumbled and must be plated all over is done in horizontal barrels 6 x 14 in. in inside dimensions. The parts are cleaned by hand in baskets. Leaded brass parts are first copper plated and then gold plated, but gold is plated directly on parts made from lead-free brass. Ampere-minute meters control the amount of plating, and are so connected into the circuit that they shut off the current when the predetermined plating time is reached. The use of de-ionized water for makeup and rinsing eliminated many of the troubles encountered when city water was used.

Systems for recovering gold from rinse waters are incorporated in both the automatic plater and barrel plating sections. The rinse waters are circulated through cylinders filled with zinc shavings. Zinc replaces gold in the solution, and the gold sludge (plus surplus zinc shavings) is removed periodically and the values reclaimed.

Sherardizing — On deep drawn

Fig. 3 — General View of Automatic Gold Plating Machine and Some of the Auxiliaries. The side of the loop shown contains the equipment for nickel undercoat; the far side (return) of the loop contains the gold tanks



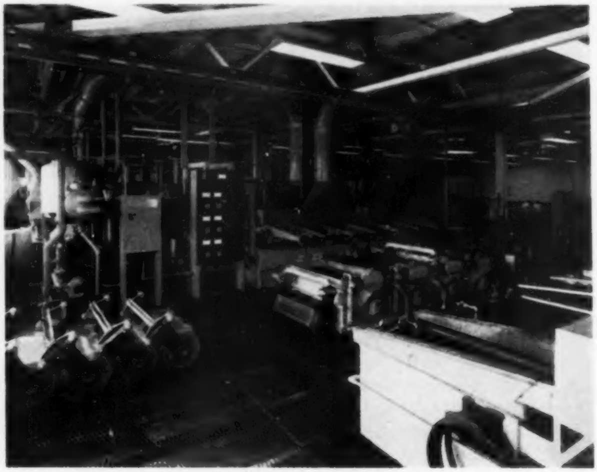


Fig. 5 — Horizontal Barrel Plating Facilities for Passivated Zinc Plate Finish

steel parts which require a finish on the inside it has been found more economical to apply zinc by sherardizing than by plating. This process, although quite old, is not used extensively because of the unpleasant bluish gray appearance of the finish. However, it affords good protection against corrosion and can be used as a base for baking enamels.

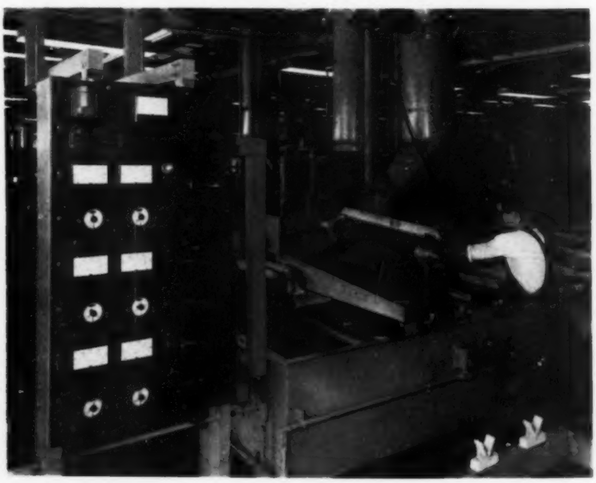
The sherardizing equipment consists of a metal drum 3 ft. in diameter and 5 ft. long, into which the parts are loaded along with zinc dust, zinc oxide, and clay. The drums are revolved in an electric furnace until they reach 780° F., just below the melting point of zinc. The time the load is held at this temperature determines the thickness of the coating. The drum is then transferred to a cooling chamber in which it revolves until cool enough to open. Coatings up to 0.002 in. thick can be applied by this process.

Coatings on Aluminum — Both the anodizing and Alrok processes are used to protect aluminum. The Alrok finish is used most because it is generally adaptable to bulk handling methods and requires much less investment for equipment — no plating current is required. Rack maintenance is also eliminated. The equipment consists of steel tanks in which the parts are revolved in barrels made of stainless steel mesh. The parts are processed, rinsed, sealed, and dried in the barrel.

The anodized finish is used primarily for its insulating properties; hence, uniform conditions in the anodizing bath must be maintained to form a dense coating without a powdery surface. The parts are placed in phenol fabric racks with aluminum contacts; they are anodized in a 10% sulphuric acid solution in a Haveg plastic tank. Temperature is automatically controlled within close limits by pumping the anodizing solution through an external Karbate heat exchanger; a single heat exchanger is used for both heating and cooling. Monel sheet cathodes provide the maximum unobstructed space inside the tank.

After anodizing, the parts are rinsed in water and immersed in a boiling sodium dichromate solution which seals

Fig. 4 — Close-Up of Control Panel and Plating Tanks



the coating and gives a light color, distinguishing them from unfinished parts. Since these parts are used in the telephone transmitter, they must be as clean as possible, chemically and physically, to avoid contamination of the carbon in the transmitter. All solution and rinse tanks (except the anodizing tank) are made of stainless steel; finished parts are rinsed in de-ionized water.

Cleaning and Degreasing — Cleaning of parts between manufacturing operations and before delivery to the metal finishing department is carried out almost entirely in degreasers using either trichlorethylene or perchlorethylene. Most of the degreasers are automatic, but hand degreasers are used where the volume of work is too small to justify the more costly equipment. The automatic machines are usually of the liquid-liquid-vapor type; the hand machines vary according to the individual job.

The automatic degreasers are capable of handling 3000 to 6000 lb. of work per hr. or cleaning the equivalent of 90 to 180 cu.ft. per hr. Trichlorethylene degreasing is greatly favored because it produces clean and dry parts immediately, and the cost for cleaning a large quantity of small items compares favorably to alkaline or other types of cleaning.

Passivation of Zinc — More than 90% of the zinc-plated parts are subsequently given a chromate treatment to passivate the zinc finish. The mechanics of the chromate treatment is incorporated directly into the process in both the automatic plater and the barrel plating section (see Fig. 5), so that the extra labor cost for this additional protection is held to a minimum. The chromate treatment is also given to certain zinc die castings that are exposed to moisture.

Organic Enamels used on the various parts of the telephone are mostly of the oil-modified, Alkyd resin, baking type; such films have good adherence as well as good impact and abrasion resistance. Both hot and cold spraying methods are used. By hot spraying, a 0.0015-in. coating can be applied in one operation without runs or sags. Baking ovens are of continuous and of batch type. They are convection ovens, heated air being recirculated at a relatively high rate for uniform conditions in all parts of the oven.

De-Ionizing for Pure Water

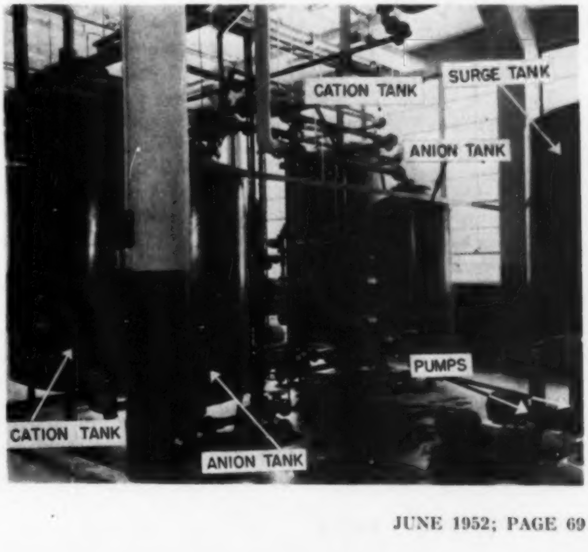
Wet tumbling, steel blasting, and polishing and buffing are also used to prepare surfaces for various finishing operations.

Water Purification — Indianapolis, the new location selected for this telephone manufacturing plant, is in an area of relatively hard water. It was therefore decided to install de-ionizing equipment to supply water for the plating solutions and cleaners, and for rinsing.

The de-ionizing equipment, partly shown in Fig. 6, consists of two parallel units, each of which will deliver, before regeneration is necessary, 70,000 gal. of water of 0.5-grain hardness at the rate of 70 gal. per min. If an extra heavy demand is encountered at a particular time, the two units may be operated in parallel. The regeneration cycle is automatically controlled through seven steps, including back washing to remove silt and reclassify the grain size in the exchange resin beds, chemical regeneration of the resins, and washing free of regenerant solution. Purified water is transmitted in a piping system of aluminum.

De-ionized water is much cheaper than

Fig. 6 — Some of the Facilities for De-Ionizing Water Used for Plating Solutions and Rinse Tanks. Raw hard water gives up its calcium and magnesium to a resin in the cation tank, then gives up its chloride and sulphate ions to a second resin in the anion tank, and finally is freed from CO_2 in a spray tower



distilled water and sufficiently pure for many exacting industrial purposes. It has eliminated the precipitation of calcium carbonate in the copper solution, assisted in obtaining better characteristics on contact surfaces in the telephone transmitter, and given a better surface on which to fire the white enamel used on the number plates.

Acid Handling — The nitric and hydrochloric acids used in the plating processes are delivered to the plant in tank cars and boosted by air pressure to elevated storage tanks. Portable tanks of approximately 300-gal. capacity are filled by gravity from these storage tanks and trucked to the metal finishing department as needed. They are then connnected to the acid distributing system, and compressed air at 5-lb. pressure forces the acid into the system. Liquid caustic soda is also received in tank cars. The concentration of caustic as received is 50%, and it is diluted to 20% in the storage tanks to prevent freezing. A centrifugal pump with a surge tank distributes the diluted solution to points of use. With this centralized distributing system, acids and alkalis can be purchased at no more than half their cost if delivered in carboys; the hazard of handling acids and alkalis in the plant is also greatly reduced. Acids other than nitric and hydrochloric, however, because of the small amounts required (totaling about 10% of our usage), must still be purchased in carboys; these are handled by specially designed equipment.

Waste Water from the metal finishing department is all treated before emptying into the city sewer system. The drainage from the department is handled in three systems — one for the acid and alkali waste, a second for the dilute cyanide rinse waters, and a third for concentrated cyanide wastes.

Waters from the acid and alkali rinses and discarded solutions of acids and alkalis flow by gravity through one drainage system into the first of a series of six 3000-gal. tanks. The first four tanks are equipped with baffles, and the fifth with a mechanical agitator, which mix the wastes as they progress from tank to tank to change the pH of the solutions at a reasonably constant rate. The last tank is also equipped with an agitator. 20% caustic is added to this last tank to bring the solution to a pH above 6.0. The caustic addition is controlled by a Leeds & Northrup Speedomax pH controller which operates proportioning valves.

The dilute cyanide rinse waters are treated by alkaline chlorination to transform the cyanides to cyanates. These wastes flow in a separate drain through the chlorine room to two 6000-gal. retention and mixing tanks equipped with mechanical agitators. The system will operate with one of the tanks if the other tank must be disconnected for repair or desludging; thus there is no interruption to production. Chlorinators inject chlorine into the waste by pumps which draw dilute waste from the retention tanks instead of city water. A pH higher than 8.5 is maintained during treatment by adding 20% caustic solution to the pump intake. Periodic checks are made to maintain a chlorine residual and the proper pH in the first tank. The waste then flows to the second, used for settling the resulting sludge or for further treatment of the cyanates.

Concentrated cyanides from the disposal of contaminated cyanide cleaners and rinse water from the cleaning of cyanide plating tanks are completely oxidized by alkaline chlorination. These wastes are collected in a 2000-gal. holding tank. Batches are drained from this holding tank into a 750-gal. treatment tank. Titrations are made, and from tables the operator determines the amount of caustic soda and chlorine required to treat that particular batch. Liquid caustic is added, and the batch is chlorinated at a definite rate until the approximate amount of chlorine has been added. As a further check against overchlorination and the chlorination of an acid solution, a sample is drawn every 15 min. and checked for pH and chlorine residual. After a positive test is obtained for residual chlorine, the treated material is held for 30 min., and a second check is made.

A recirculating cooling water system installed at the plant consists of a cooling tower, pump house, and zeolite softener system. This water is used in other parts of the plant as well, so it is important that none of the chemical solutions being cooled get into the system. To safeguard against this, the pH of the water entering and leaving the metal-finishing department is noted by a Leeds & Northrup recording pH meter, and any marked variation in the two readings is immediately investigated. The recirculating system not only saves water but provides better cooling during summer.

By S. L. Widrig, Chief Metallurgical Engineer, and Wilson T. Groves
Metallurgical Engineer, Spicer Mfg., Division of Dana Corp., Toledo, Ohio

Forgeability, Machinability and Hardenability of Boron Carburizing Steels

Recent efforts by the producers and consumers of high-grade steels for machine parts to conserve alloys are reminiscent of World War II. It was early concluded that we would have to resort extensively to boron-treated steels, and a large and active group of metallurgists (Boron Steel Committee of Division VIII of the Iron and Steel Technical Division of Society of Automotive Engineers and the American Iron and Steel Institute) has collected and circulated a great amount of useful information about these steels.

One group of the standard steels favored by the automotive industry is the 8600 series — which, it will be remembered, are "triple alloy" steels developed in the early 1940's to conserve scarce alloys. At the time the Boron Steel Committee stepped up its activities, molybdenum was the only metal actually restricted by governmental fiat. Attention was therefore given to a modified 8600 known as TS8600 wherein the molybdenum was reduced to the range 0.08 to 0.15% (from 0.15 to 0.25%), and counterbalanced to give about the same hardenability by increasing the chromium from the 0.40 to 0.60% range to 0.55 to 0.75%. The 8600 and TS8600 series had very similar characteristics, but even the latter became difficult to obtain.

In order to increase the probability of an adequate and continuous supply of steel at Spicer Mfg. Corp. we thought it advisable to get down to the lowest alloy possible without jeopardizing the quality of our product. We were warned that even the 8100 series and the 94B00 series might not be available for civilian use, and it was suggested that we try the entirely inadequate 14B00 (about 1.30% Mn). We concentrated our efforts on the 80B00 steels containing alloy percentages only slightly above that derived from residuals in the melting scrap.

Our development program was successful, and approval was granted for the use of 80B17 for all carburized gears and 80B20 for all carburized shafts for regular production. These steels have replaced 8620 in heavy-duty automotive transmissions (and, to a lesser extent, carburized products made in other plants of the Dana Corp.).

This article should not be considered as a testimonial for boron steels in the carburizing grades, despite the fact that we have been using them successfully in production for several months. As will be seen later, we have had more distortion trouble than with 8620, particularly in light sections. This has also been reported by many others, and it was recently proposed by the American Iron and Steel Institute that the 80B00 steels up through 80B25 be deleted from the list of tentative standards. (It is now believed that the 8100 and the 94B00 series steels will be generally available.) This proposal was voted down by Division VIII on the basis that we should learn all we can about these very low alloy steels, in the event we are suddenly forced to use them in a future emergency. This is the justification for publishing a rather full account of our experiences.

Despite the large amount of general information made available through technical groups, it is still necessary for each plant to solve its own specific problems. This is, of course, due to variations, from plant to plant, in processing methods, design of parts, and type of service. It appeared that the following considerations should be investigated: forgeability, machinability, hardness of core and case, distortion, and performance in service or simulated service tests. These items will now be discussed in the order listed.

Forgeability — We have been unable to detect any detrimental effect of boron on

forging properties. A slight increase in die life was expected, due to the less tenacious scale on this steel of very low nickel content, but we have no actual data.

Reports that 0.005 to 0.008% boron causes hot shortness are of no significance, since the full effect of boron on increasing hardenability of properly deoxidized openhearth steel requires less than 0.001%. (Heats analyzed by spectroscopic method in our laboratory have been of this order of magnitude.)

Annealed boron steels will be somewhat softer than higher alloy steels of equivalent hardenability after going through the same furnace cycle. For example, 8620 forgings run through our cycle annealing furnace have a Brinell hardness of 137 to 145, whereas the 80B20 forgings are usually in the hardness range of 126 to 134.

Machinability — Machinabilities of 8620 and 80B20 were compared on a variety of parts through operations such as turning, broaching, milling, hobbing and shaving. To eliminate as many variables as possible, alternate pieces of 8620 and 80B20 of the same part were run in the same machine. There was no significant difference in power consumption except that slightly more power was drawn when turning the softer 80B20. There was no discernible difference in surface finish. Under the above-mentioned test conditions, no correlation could be made between type of steel and tool life; however, no unfavorable reports have been received from the machine lines since the boron steels have been adopted.

Hardness of Core and Case — The 80B20 steel initially designed to replace 8620 and used in much of our preliminary testing had 0.45 to 0.70% manganese. Due to the numerous reports of excessive distortion in light sections and insufficient case hardness with heavy sections, the manganese content was later raised to 0.60 to 0.90%, and lower carbon grades such as 80B15 and 80B17 were made available. Figure 1 shows hardenability of case and core of 4 heats of 80B20 and 11 heats of 80B17. The curves representing average values cross at 6/16ths on the Jominy bar. Since distortion is influenced primarily by core hardenability, it would then appear questionable if there would be any real advantage in minimizing distortion, in changing from the original 80B20. Actually we detected little difference in distortion. As expected, there was a slight increase in case hardenability (using depth to C-60 as a criterion) both in the carburized Jominy bars and in actual practice.

Figure 2 plots core hardenability of the 11 heats of 80B17 and the hardenability bands of 8620H and 4320H. At 5 to 6 sixteenths the average hardnesses of 80B17 correspond to the maximum hardness values for 8620H. It could then be expected that in light sections, where the average cooling rates correspond to this portion of the Jominy bar, we would get somewhat more distortion with 80B17 than with 8620. Figure 2 also shows that the maximum curve for 80B17 closely approaches the maximum 4320H curve at 5 to 8 sixteenths. It will be seen later that parts of these two steels behave similarly during quenching.

Probably the chief limitation of boron is the decrease in effectiveness as carbon content increases in the steel. This phenomenon has been known and studied for many years. See, for example, the summary published by Rahrer and Armstrong ("The Effect of Carbon Content on the Hardenability of Boron Steels") in *Transactions* ⊛ for 1948, p. 1099. Its effect on promoting hardenability was found to become nil at carbon contents varying from 0.70 to 1.0% by the four investigators quoted. Present indications are that boron still has some effect

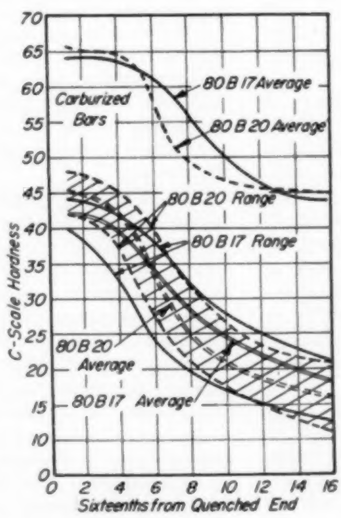


Fig. 1 — End-Quench Hardenability of 11 Heats of 80B17 and 4 Heats of 80B20. Values for carburized bars were taken after carburization at 1700° F., cooling to 1550, and quenching in Jominy fixture, followed by grinding to approximately the 0.90% C level. Analysis ranges were as follows:

	80B17		80B20	
C	0.16	to 0.19	0.19	to 0.22
Mn	0.65	to 0.88	0.52	to 0.63
Si	0.20	to 0.29	0.22	to 0.29
Cr	0.22	to 0.37	0.28	to 0.31
Ni	0.31	to 0.42	0.27	to 0.35
Mo	0.10	to 0.14	0.10	to 0.13
B	0.0008	to 0.001	0.0009	to 0.001

on increasing hardenability up to carbon levels as high as 0.90%.

There was consequently some skepticism throughout the industry as to whether boron-treated steels would prove satisfactory for carburized parts where there is one carbon content in the core and an altogether different range of carbon in the case. Certainly the hardenability of the case would not be proportionate to the hardenability of the core. Since boron steel substitutes are made on the basis of equivalent *core* hardenability, carburized Jominy bars should be run, in addition to those cut from steel as delivered, to predict, for new heats of steel, what surface hardness will be obtained on carburized production parts.

For illustration let us assume that a carburized shaft made from boron steel gave the required surface hardness, say, C-60, on a 2½-in. bearing diameter. At some point on a Jominy bar, made from the same heat of steel and carburized under identical conditions, there will also be a hardness of C-60. If this value is at 6 sixteenths then we could reasonably expect that any new heat of steel which would produce C-60 or better at 6 sixteenths on a carburized Jominy bar would also produce satisfactory hardness on shafts in production.

A *single* carburized Jominy bar can also be used to determine the hardness obtained with any cooling rate and at any carbon level in the range of commercial practice. The procedure is to grind 0.015-in. parallel flats on a standard Jominy bar and carburize it. After carburizing, the bar is end-quenched directly from the carburizing furnace or after reheating. Hardness readings are then taken along the length of the as-quenched surface. The bar is then slowly ground to increasing depths to obtain hardness readings at the corresponding carbon levels independently. (Use the "superficial" test, since the deeper penetration of C-scale readings represents an average hardness over a range of carbon content.) The cooling rate at any particular distance on the bar will not vary much with radial depth since practically all the cooling is from the quenched end — at least in the first inch of the bar in which we are primarily interested.

Fig. 2 — Comparison of Hardenability of 80B17, 8620H and 4320H. Quenching temperature was 1700° F.

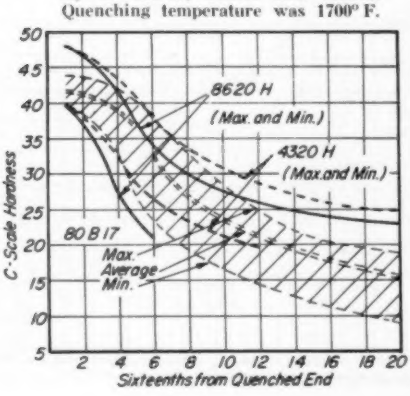


Figure 3 is a plot from such a test made at Spicer for 8620 and 80B20 steels. Core hardenability of the 80B20 is greater but the case hardenability is far less. Maximum hardenability for 80B20 and 8620 is obtained at 0.92 and 0.83% C, respectively. These results agree well with those found by other investigators. If we, therefore, must obtain maximum surface hardness on heavy sections of boron steel, we should control our furnace atmospheres or carburizing compound so as to produce surface carbon in the range of 0.90%. (The curves can be altered somewhat by deep freezing to transform retained austenite, but this is impractical from a production standpoint.)

It therefore appeared that adequate surface hardness should be obtained on carburized parts of 80B20 when the size was such that the surface cooling rate would be equal or greater than the cooling rate prevailing at 5/16 in. on the hardenability bar (about 60° F. per sec. at 1300° F.). For heavy section sizes where the cooling rate corresponds to a distance of, say, 8 sixteenths on the hardenability bar, the 80B20 may be as low as C-48, whereas it would be C-60 or more in the same part made of 8620.

There was some doubt, then, if 80B00 would have enough hardenability in such places as needle bearing surfaces on mainshafts, or the bore of mainshaft gears, and at the root of gear teeth — particularly where the teeth are integral with heavy shafts. An even more critical location would be the tooth surfaces of hypoid pinions not ground after heat treatment; any semblance of file-soft skin will frequently cause scoring and is cause for rejection. Tooth surfaces of ring gears must also be file hard, but these are generally of light section and quenched

individually in a press, so that difficulty is seldom encountered.

Another cause for skepticism lay in the fact that many of our gears are martempered and the cooling rate is somewhat slower than in conventional oil quenching. It would, of course, be possible to increase the circulation of the martempering baths and so increase the cooling rate, but this usually requires unidirectional flow from a pump or mixer and the exposed upstream portion of a round gear receives an altogether different quench than the downstream portion. In that event much of the advantage of martempering is lost, at least as far as minimized distortion is concerned. High circulation helps with shafts quenched vertically in the direction of bath flow.

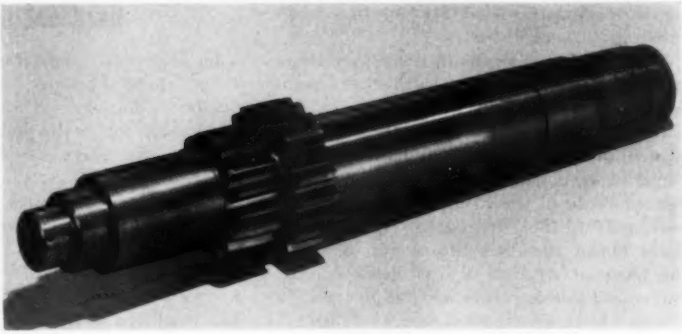


Fig. 4 — Carburized Countershaft 19½ In. Long, 2½ In. Diameter With Two Integral Spur Gears. Required hardness achieved in 80B20 steel by direct quenching from four-zone continuous gas carburizing furnace

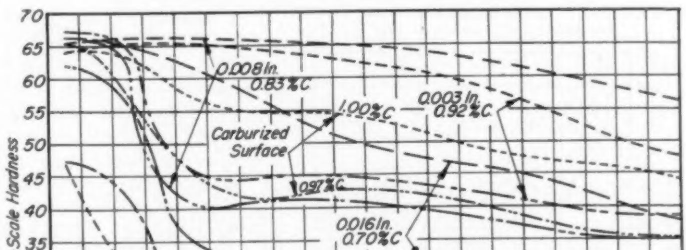
Behavior in Production — We set up a test program in which parts for one of our largest transmissions would be made from both 80B00 and 8600 steels, processed simultaneously, and later tested on the dynamometer stand.

The heaviest part was the 28-lb. countershaft shown in Fig. 4, 19½ in. long, 2½ in. diameter. Integral with the shaft were two spur gears of 6-7 pitch, one with 16 teeth 1½-in. face, and the other with 21 teeth 1⅛-in. face. First we used the reheat cycle long employed for clash teeth gears, namely, carburizing at 1700° F., cooling to 1150, and reheating to 1550 — all in a four-zone continuous atmosphere furnace. The shaft hardness following an oil quench and draw was not consistently within the specified C-59 to 62 when the 80B20 parts were run in a production manner, namely, supported horizontally on saddles, four pieces per tray, quenched tray and all. Subsequent parts were run in a similar four-zone furnace employing a direct quench cycle consisting of carburizing at 1700° F. and cooling to 1550 in the

Table I — Hardness Penetration in Countershaft

Depth	Shaft	Large Gear		Small Gear	
		Pitch Line	Root	Pitch Line	Root
0.005 in.	—	—	—	—	C-59.5
0.010	C-61	C-62.5	C-60.5	C-62	57
0.020	55.5	60.5	54.5	60	51
0.030	48.5	56.5	48	55.5	43
0.040	43.5	52.5	43	50.5	36
0.050	38	49	39	46.5	34
0.060	34	46.5	36.5	44	32
Core	—	41	36	41	32

Fig. 3 — Hardness-Distance Curves for Carburized and End-Quenching Jominy Bars of 8620 and 80B20 (Grain Size 6 to 7), at Surface and at Various Depths Below Surface Down to Uncarburized Core. Carburized at 1700° F., quenched from 1550° F. (Vickers 5-kg. readings have been converted to Rockwell C-scale hardness)



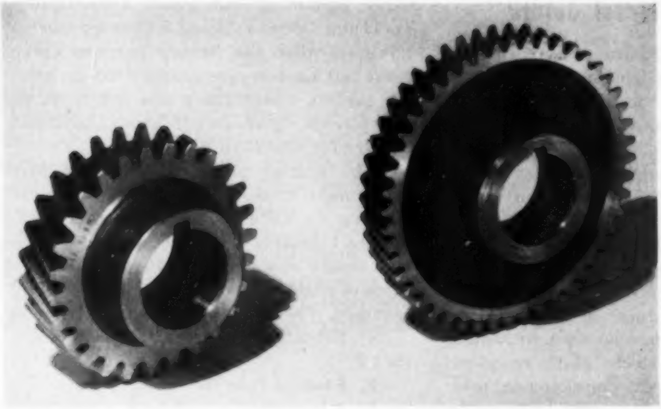


Fig. 6 — Gears Studied as to Hardness Penetration in Carburized Case

furnace prior to oil quenching horizontally on the tray with an automatic elevator. Hardness gradients in the case at tooth pitch line and root line and shaft o.d. after such direct quenching and tempering at 340° F., shown in Table I, indicate that the C-59 to 62 hardness specification was met in all locations.

This greater surface hardness was attributed to two factors, namely, increased hardenability inherent with direct quenching as compared to reheating, and lower surface carbon with the direct quench cycle.

Surface hardness on a carburized "step-down" bar is shown in Fig. 5 after treatments noted in the caption. It was machined from the same heat of steel as the countershaft described above. The hardnesses after direct quenching are higher than after reheating, quenching and drawing, particularly on the larger sections. It appeared then that in order to obtain satisfactory case hardness on the leaner alloy boron-treated steel we would have to abandon the reheat cycle formerly used for clash teeth gears. This change was actually made.

Gear Studies — Two fairly large gears made from 80B20 were also studied. One was the countershaft gear shown at the left of Fig. 6. Such gears were made from 8620 and 80B20 steels and heat treated simultaneously. The hardness gradient of the countershaft gear of 80B20 compares favorably with one made of 8620 at the pitch line of the tooth but is appreciably lower at the root line where the cooling rate is somewhat slower. This result might be predicted from hardenability curves of carburized Jominy bars (Fig. 3). The pitch line hardness just under the surface at the pitch line of the 8620 gear is somewhat lower than on the 80B20 gear due to the greater amount of retained austenite (approximately 10 to 15% of the microstructure in 8620 compared to 2 to 5% in the 80B20). The core hardness for both the pitch line and root is substantially equal for both steels.

Fig. 5 — Stepdown Bar Made From Countershaft Steel. Carburized at 1700° F., cooled to 1550, oil quenched and drawn at 340° F. Average surface hardnesses noted at right are after reheating to 1550° F. in carburizing atmosphere, oil quenching and drawing at 340° F.

Table II — Hardness Penetration in Countershaft Gear Made of 80B17★

Jominy Hardenability			Hardness Penetration in Case			
Sixteenths	Annealed	Carburized	Depth	Pitch Line	Root Line	Bore
1	C-42	C-65	0.005 in.	C-62	C-60	C-60
2	41	64	0.010	62	60	57.5
3	41	64	0.020	60	57.5	52
4	40	63	0.030	55.5	54.5	45.5
5	40	62	0.040	52	48	40
6	37	61	0.050	47	44.5	37
8	30	60	0.060	44	42	35
12	24	50	0.070	42	41.5	—
16	20	45	0.080	41.5	41	—

★Analysis: 0.17% C, 0.21% Si, 0.88% Mn, 0.34% Ni, 0.37% Cr, 0.10% Mo, 0.001% B

Gears, Pinions and Universal Joints

Table II shows hardness gradients across the case at the tooth pitch line and root line and also the bore of the keyed-on countershaft gear of comparatively light section shown at the right of Fig. 6. This gear is about 6¾ in. pitch diameter; its web rim and hub are about ¼ in. thick. The gear under study was made from 80B17 steel and martempered. Because of the geometry of this part it has always been a bad actor as far as distortion is concerned. The values indicate that the case hardness falls off rapidly in the bore — much more so than we would experience with 8620 steel. With keyed-on gears this is of no great consequence, providing the hardness after grinding is sufficient to prevent scuffing during assembly. On many mainshaft gears, however, the bore acts as an outer race for a needle bearing, and high hardness is required to prevent wear and brinelling.

Experimental lots of pinions, ring gears and pinion mates were processed by production methods, with good results as far as surface hardness was concerned. The steel (80B20) is the one whose hardenability curves both before and after carburization are shown in Fig. 3. The largest of these was a pinion having 12 teeth of 5.529-in. pitch, a 3.420-in. maximum head o.d. and 1.376-in. shaft. These were racked vertically, head down, 21 pieces per tray, carburized at 1700° F. in continuous gas carburizer, and quenched from 1600° F. on the tray in an oil bath recirculated by a 500-gal.-per-min. pump. The teeth were mill-file hard after quenching. There was a very superficial file-soft skin on the shaft on both the 8620 and 80B20 parts; this is ground after heat treatment and a bearing pressed on.

The ring gears and pinion mates were of comparatively light section and were also mill-file hard after quenching.

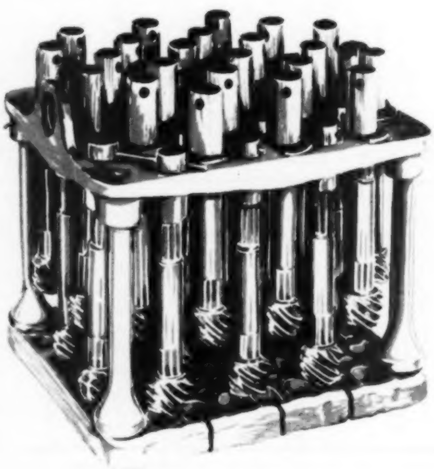
Universal Joints — Our experience is that to obtain file-hard surfaces free from burns after grinding it is necessary that universal joint journal crosses be definitely file hard and without skin before grinding. The largest journal made from boron steel during the development program was 5¾ in. long overall and had trunnions of 1⅜-in. outside diameter with a ⅝-in. diameter hole drilled through them. The steel had substantially the same chemical analysis as the 80B20 of Fig. 3, except for 0.22% C. Despite this higher carbon it had lower hardenability (C-43 and C-40 at 1/16 and 5/16 respectively); however, when the Jominy bar was carburized and hardness measured 0.008 in. below the surface where there was 0.93% C, the end-quench curve duplicated the 0.92% C-curve for 80B20 in Fig. 3.

The normal processing of these parts when made from 8620 steel consists of carburizing to 0.050 to 0.056 in. at 1700° F., cooling, reheating to 1580° F. and oil quenching, finally drawing at 320° F. The first batch of 80B20 parts so processed had spotty hardness. The following changes were made:

1. Reheating temperature was raised to 1625° F.
2. Soaking time increased slightly.
3. A less viscous quenching oil was used.
4. A 750-gal.-per-min. recirculating pump installed in the quench tank.
5. Draw temperature decreased to 275° F.

The net result was that the parts had a surface hardness on the high side of the C-62 to 59 range specified and were uniformly file-hard on the trunnions. The core hardness was C-41 to 39. Many such journals made from both 80B17 and 80B20 have since been run in production and no difficulty has been encountered with soft surfaces.

The second portion of this article, to be published in the July issue, will describe some difficulties encountered in production from distortion during heat treatment. Results of fatigue tests and of simulated service tests to determine resistance to chipping will also be included.



By Allen G. Gray, Consulting Editor to Metal Progress

Hard Chromium Plate and Bright Plating of Steel or Die Castings

THIN, BRIGHT films of chromium for tarnish resistance and decorative appeal have many well-known applications in metal finishing. In addition to its eye appeal, electrodeposited chromium has valuable properties in a number of strictly engineering uses. This type of chromium plate is generally termed "hard chromium". It is, indeed, harder than any other commercially plated metal. The life of certain tools can be prolonged by chromium plating to proper thickness. In addition, it has a low coefficient of friction and nongalling properties, together with good resistance to corrosion at both ordinary and elevated temperatures.

Wearing surfaces can frequently be improved by chromium plating. Spindles, shafts, pistons and machine parts subject to wear or scuffing were at one time plated principally for salvage and reuse after being worn down below limits. Often these salvaged parts outlasted the originals, and thus reduced maintenance requirements and conserved labor and strategic materials. The low coefficient of friction of chromium against other metals is an important factor in its long life on shafting, piston rings, internal combustion engine cylinders and similar applications. Figure 1 shows a production setup for hard chromium plating small shafts, and illustrates one necessary qualification, namely that conforming anodes are necessary if coatings of uniform thickness are to be deposited.

Chromium plating may also be used to salvage new parts that are undersize due to errors in machining or grinding. Figure 2 shows a propeller shaft that has been salvaged by a 0.010-in. chromium plate on splines and journal.

SELF-REGULATING CHROMIUM PLATING BATH

The plating solution which has had almost universal use is chromic acid-sulphate, most generally one of the compositions shown at the bottom of the opposite column. The correct ratio of chromic acid to sulphate catalyst is important for successful operation. In industrial plating, this ratio is usually kept close to 100 to 1. A large amount of work has been done with this system over a period of years.

At the 37th Annual Convention of the American Electroplaters' Society, investigators for United Chromium, Inc., described a high-speed bath, termed the "S.R.H.S." bath. Perhaps its most interesting characteristic is that it is automatically self-regulating within narrow limits with respect to mixed and cooperating catalytic acid radicals at any chosen chromic acid concentration and temperature. Baths have been commercially operated at wide ranges in concentrations to meet a variety of plating requirements — for example 150 to 500 g/l. (20 to 67 oz/gal.) at 27 to 66° C. (80 to 150° F.).

These baths apparently give higher current efficiencies and accept higher current densities than conventional baths, as indicated in Fig. 3. Deposits are described as generally smoother with less tendency toward nodular growths, treeing and pimpling than in conventional baths. In one shop the plating time of 5½ hr. for a certain thickness of hard chromium was reduced to 3½ hr. with the "S.R.H.S." bath.

Activating effect is another important characteristic, accounting for their ability to plate better over passive nickel and to withstand current interruptions better without pronouncedly dull and streaked deposits. The ability to do a better job in plating chromium on chromium has practical application in salvage of "misplates". Better cov-

Bath Composition	Low Concentration	High Concentration
Chromic acid (CrO_3)	33.0 oz/gal.	55.0 oz/gal.
Sulphuric acid (H_2SO_4)	0.33 oz/gal.	0.55 oz/gal.

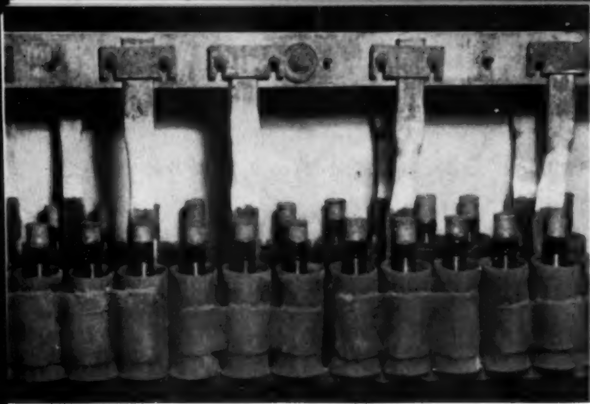


Fig. 1 — Series of Conforming Anodes for Carrying Small Shafts Through a Hard Chromium Plating Bath. (Courtesy Nutmeg Chrome Corp.)

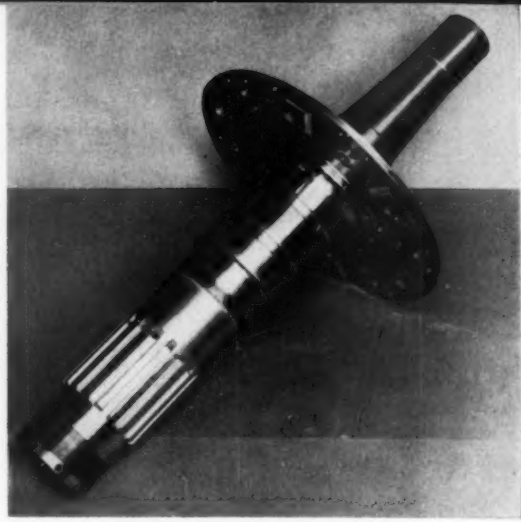


Fig. 2 — Propeller Shaft, Salvaged by 0.010-In. Chromium Plating of Splines and Journal

erage, another advantage claimed for the self-regulating type of bath, has increased production in some plants by permitting more pieces per rack. In one shop where tail-pipe extensions were being plated, production was doubled because parts could be racked back to back; in another plant, the same rack and the same rack spacing were used in both the chromium and the nickel plating baths.

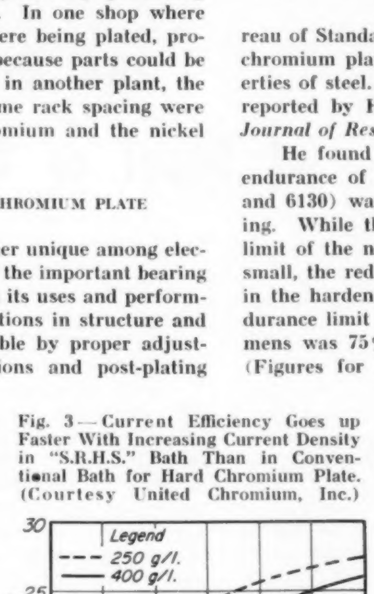
PROPERTIES OF CHROMIUM PLATE

Chromium is rather unique among electrodeposits because of the important bearing its structure has upon its uses and performance. Actually, several variations in structure and physical properties are possible by proper adjustment of the plating conditions and post-plating treatments. Structural changes taking place on heating chromium plate are those normal for a highly stressed, fine-grained metal. C. L. Faust and C. A. Snavely of Battelle Memorial Institute have recently presented data before the 1950 meeting of the Electrochemical Society to show that recrystallization occurs during prolonged heating between 300 and 500° C. (570 and 930° F.), or on shorter times at higher temperatures. The new grains are elongated normally to the base metal.

Studies have been conducted at the National Bureau of Standards to determine the effect of chromium plating on the mechanical properties of steel. One phase of this work was reported by H. L. Logan in the Bureau's *Journal of Research*.

He found in his investigation that the endurance of aircraft steels (S.A.E. X-4130 and 6130) was reduced by chromium plating. While the decrease in the endurance limit of the normalized steel was generally small, the reduction by plating was greater in the hardened steels. The minimum endurance limit of any group of plated specimens was 75% that of the unplated steel. (Figures for most sets of test specimens ranged from 83 to 95.5%.) The endurance limit of specimens heated after plating reached maximum value for baking temperature between 190 and 300° C. (375 and 575° F.).

Fig. 3 — Current Efficiency Goes up Faster With Increasing Current Density in "S.R.H.S." Bath Than in Conventional Bath for Hard Chromium Plate. (Courtesy United Chromium, Inc.)



Other Bureau of Standards studies reported in *Journal of Research* in 1951 evaluated the effect of chromium plating on the plastic deformation of S.A.E. 4130 steel by ordinary tensile, tensile impact, bending and crushing tests. Test pieces were plated in an electrolyte containing 250 g/l. of chromic acid and 2.5 g/l. of sulphuric acid at 55° C.,

(Continued on p. 170)

By **Francis Kayser**, Research Division, General Motors Corp., Detroit
and **Morris Cohen**, Dept. of Metallurgy, Massachusetts Institute of Technology

Carbides in High Speed Steel — Their Nature and Quantity*

EXCESS CARBIDES not only exert a direct influence on the properties of high speed steel, but govern the composition of the matrix through the degree of solution effected by the austenitizing treatment (high heating prior to quenching). This in turn controls the hardening and tempering characteristics of the steel. Techniques for isolating carbides quantitatively have recently been described by Blickwede and Cohen in *Transactions* of the American Institute of Mining and Metallurgical Engineers, 1949, p. 578, and it would seem desirable to extend these techniques to the various grades of commercial high speed toolsteels. This is the purpose of the present communication.

The eight steels selected are listed in Table I. They are typical of the current grades. Group I comprises the high-tungsten steels, including two cobalt types of which one contains high carbon and high vanadium as well. Group II comprises the molybdenum grades, in which all or part of the tungsten has been replaced. One of these contains high carbon and high vanadium.

All the steels were obtained from Vanadium-Alloys Steel Co. They were ¼-in. centerless-ground bars from commercial heats, and were received in the annealed (spheroidized) condition. Six-inch lengths were hardened in salt baths and quenched in oil; austenitizing (quenching) temperatures and times are given in Table I. Tempered structures were not investigated here.

Identification — The carbide phases existing in high speed steels, either annealed or as-quenched, may be distinguished by proper etching, as described at length in "The Effect of Vanadium and Carbon on the Constitution of High Speed Steel", by D. J. Blickwede, Morris Cohen and G. A. Roberts in *Transactions* ⊕, 1950, p. 1161.

Three carbides were found in each of the steels: M_6C, $M_{23}C_6$ and MC (where M represents the sum of the metal atoms). All were clearly delineated by etching with 2% nital containing zephiran chloride. The M_6C carbide was etched selectively in a 4% solution of sodium hydroxide saturated with potassium permanganate, while the MC

*Based on Mr. Kayser's thesis for S.M. degree in metallurgy at Massachusetts Institute of Technology. Grant-in-aid from Vanadium-Alloys Steel Co., Latrobe, Pa., supported this investigation.

Table I — Composition* and Heat Treatment of Steels

Grade	Chemical Composition						Minutes at Temperature						
	C	W	Mo	Cr	V	Co	1900	2100	2200	2250	2300	2350	2375
Group I — High-Tungsten Steels													
18-4-1 (T-1)	0.72	18.16	0.40	4.13	1.04	—	45	30	15	—	10	6	6
18-4-2 (T-2)	0.82	17.92	0.40	4.23	2.02	—	45	30	15	—	10	6	6
18-4-1-5 (T-4)	0.73	17.92	0.78	4.25	1.12	4.95	45	30	15	—	10	6	6
12-5-5-5 (T-15)	1.49	12.13	0.32	4.79	4.90	4.95	45	30	8	6†	—	—	—
Group II — Molybdenum Grades													
0-9-4-2 (M-10)	0.88	—	8.21	4.26	2.00	—	45	30	8	6	—	—	—
1½-9-4-1 (M-1)	0.80	1.75	8.61	3.80	1.23	—	45	30	8	6	—	—	—
6-5-4-2 (M-2)	0.83	6.38	5.25	4.22	1.92	—	45	30	8	6	—	—	—
6-5-4-4 (M-4)	1.27	5.48	4.54	4.52	4.13	—	45	30	8	6	—	—	—

*Additional elements: 0.19 to 0.31% Mn; 0.16 to 0.35% Si; 0.008 to 0.013% S; 0.016 to 0.027% P.
†This steel oil quenched after 6 min. at 2280° F.

Volume Percentages After Austenitizing

carbide was etched selectively by electrolysis in a freshly prepared 1% chromic acid solution at 2 volts.

Lineal analysis† was then used to determine the total volume percentage of the carbides and the individual percentages of M_6C and MC carbides ($M_{23}C_6$ by difference). It was necessary to polish the specimens with diamond powder to prevent the hard carbide particles from standing in relief.

All three carbides are face-centered cubic. M_6C corresponds to the complex carbide Fe_4W_2C or Fe_4Mo_2C. It not only contains variable amounts of iron, tungsten and molybdenum, but also dissolves chromium and vanadium. However, it may be regarded essentially as a tungsten-molybdenum-rich carbide.

The $M_{23}C_6$ phase corresponds to the carbide $Cr_{23}C_6$. It is also capable of dissolving iron, tungsten, molybdenum and vanadium. Nevertheless, it appears to be primarily a chromium-rich carbide.

The MC phase corresponds to the carbide VC or V_4C_3. It dissolves limited amounts of the other metallic elements, but is essentially a vanadium carbide. Tarasov has reported in *Metal Progress* for December 1948, p. 846, that this carbide is exceedingly hard, being of the same order as abrasive aluminum oxide.

AMOUNTS OF CARBIDES BY VOLUME

Volume percentages of the carbides as a function of the austenitizing temperature are given in Fig. 1. Comparative data for the annealed and commercially hardened conditions are presented in Fig. 2. Of course, all the steels exhibit the maximum volume of carbide in the annealed condition with the amounts decreasing progressively the higher the austenitizing temperature.

Generally speaking, the tungsten grades of Group I contain a larger volume of total carbides than the molybdenum-bearing steels of Group II. However, 6-5-4-4 steel M-2 overlaps both groups. The 18-4-2 steel has the largest carbide volume, while 0-9-4-2 has the smallest.

†"Quantitative Metallography by Point Counting and Lineal Analysis", by R. T. Howard and M. Cohen, *Transactions*, A.I.M.E., 1947, p. 413.

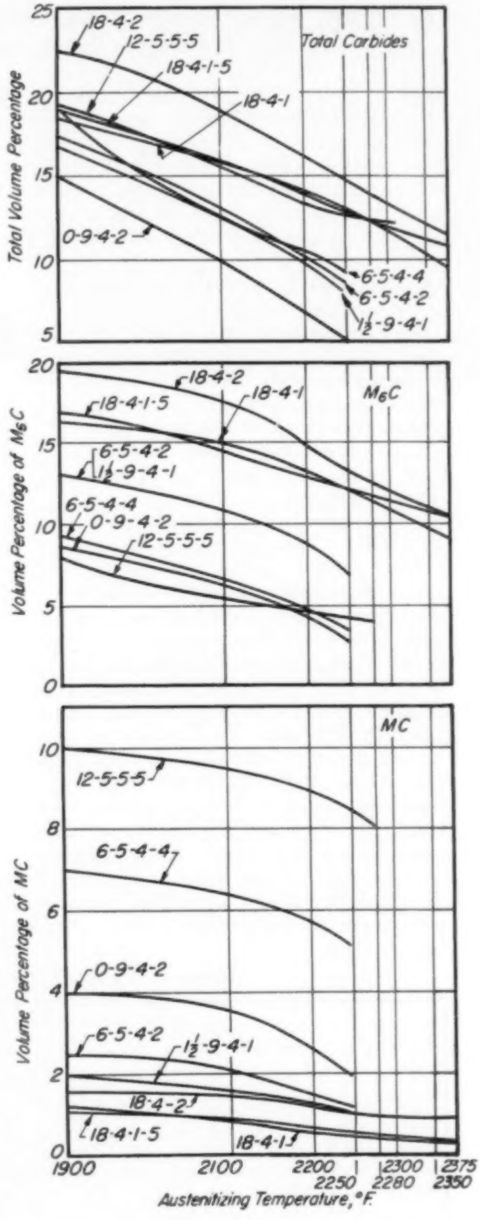


Fig. 1 — Volume Percentage of M_6C, MC and Total Carbides in Eight Commercial High Speed Steels After Oil Quenching From Temperatures Indicated. Amounts decrease progressively the higher the austenitizing temperature

In the annealed state, all the steels contain 9 to 11% $M_{23}C_6$ as shown in Fig. 2. This carbide dissolves at comparatively low temperatures during austenitizing; only 0.8 to 2.6% remains after quenching from 1900° F. As a group, the molybdenum-bearing steels seem to require slightly higher temperatures for complete solution of the $M_{23}C_6$. This may result from the fact that the molybdenum has a greater tendency than tungsten to enter the carbide under the prevailing conditions. In any case, the $M_{23}C_6$ dissolves entirely on austenitizing below 2100° F., and furnishes the carbon in solution which is responsible for the martensitic hardening of high speed steels upon quenching from such relatively low temperatures.

The volume percentages of M_6C and MC are plotted in Fig. 1. Usually the tungsten-molybdenum-rich M_6C carbide predominates. Except for the 12-5-5-5 steel, wherein the high vanadium content competes for the available carbon to form a relatively large percentage of MC, the tungsten grades contain more of the M_6C carbide than do the molybdenum-bearing grades. The same comparison can be made between the 6-5-4-4 and the 6-5-4-2 steels, the former containing less M_6C and more MC than the latter. It is also evident that, in the presence of a given vanadium and carbon content, tungsten competes more effectively than molybdenum to promote the formation of M_6C. For example, in the series 18-4-2, 6-5-4-2 and 0-9-4-2, the amount of M_6C decreases while that of MC increases.

It is clear from Fig. 1 and 2 that the percentage of MC increases with the vanadium content. There is one exception, namely, the 1½-9-4-1 steel which contains more MC over part of the austenitizing range than 18-4-2, but this is only a reflection of the higher tungsten in the latter which competes more strongly for the carbon to form larger quantities of M_6C. For the same reason the 0-9-4-2 steel (without tungsten) contains a substantial quantity of MC. In the 6-5-4-4 and 12-5-5-5 steels, the amount of MC becomes quite large, being commensurate with that of M_6C.

Table II — Percentage of Total Carbide Existing as MC in High Speed Steel

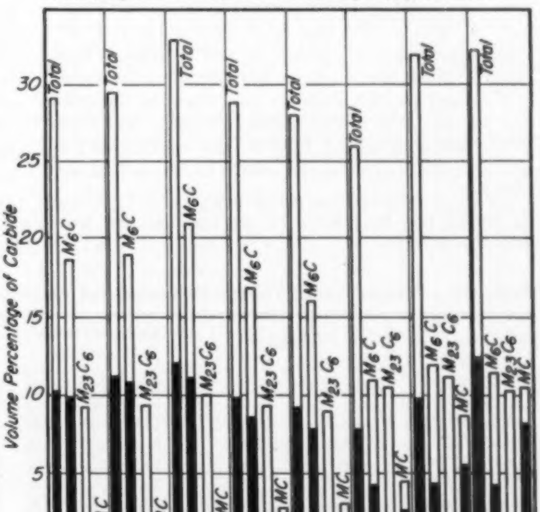
GRADE	ANNEALED	AUSTENITIZED*
18-4-1 (T-1)	4%	3% (2350° F.)
18-4-1-5 (T-4)	4	4 (2350° F.)
18-4-2 (T-2)	6	8 (2350° F.)
1½-9-4-1 (M-1)	10	13 (2200° F.)
6-5-4-2 (M-2)	11	15 (2225° F.)
0-9-4-2 (M-10)	17	39 (2200° F.)
6-5-4-4 (M-4)	28	56 (2225° F.)
12-5-5-5 (T-15)	33	66 (2280° F.)

*Commercially hardened.

Annealed Versus Hardened States — It is instructive to compare the annealed and the commercially hardened conditions. This is done in Fig. 2, in which the steels are arranged in order of increasing MC contents. Despite the many variations, certain similarities are apparent.

As a result of commercial austenitizing, all the steels dissolve about the same volume of carbide existing in the annealed state — 7 to 10% M_6C, 9 to 11% $M_{23}C_6$, 1 to 3% MC (18 to 22% total). This surprising regularity is probably attributable to the fact that the development of each one of these steels over the years involved an empirical matching of composition with heat treatment in

Fig. 2 — Volume Percentages of Carbides in High Speed Steels. Open bars indicate amounts in annealed steel; black bars indicate amounts after austenitizing at commercial hardening temperatures



an effort to secure similar hardening and tempering characteristics. However, on the basis of the amount of carbide remaining in the hardened structure, the volume percentages shown by the black portions of the graph vary from 7% for the 0-9-4-2 steel to 12½% for the 12-5-5-5.

Figures 1 and 2 also disclose a wide range in the volume percentages of the hard MC carbide among the commercially austenitized steels. The absolute values vary from 0.3% in 18-4-1 to 8.2% in 12-5-5-5. Such differences become more apparent when the MC content is expressed as the per cent of the carbide volume (rather than of the steel itself). This is shown in Table II (p. 81) for both annealed and commercially hardened conditions. After austenitizing, the percentage of total carbide existing as MC ranges from 3% in 18-4-1 to 66% in 12-5-5-5. Furthermore, the proportion of MC in most of the grades is larger after commercial hardening than in the annealed state. This difference increases with the absolute amount of MC in consequence of its relative reluctance to dissolve during austenitizing.

AMOUNTS OF CARBIDES BY WEIGHT

The carbides were isolated electrolytically in the type of hydrochloric acid cell described by Blickwede and Cohen. A 6-in. length of each ¼-in. bar served as the anode and an 18-8 stainless steel sheet as the cathode. For the annealed specimens and those austenitized at 1900° F. the electrolyte was 1:10 hydrochloric acid, the anode current density was 0.15 ampere per sq.in., and the time of extraction was 24 hr. Better results were obtained with the specimens austenitized above 1900° F. (less dissolution of the released carbides in the electrolyte) by decreasing the HCl acid concentration to 1:25, increasing the anode current density to 0.30 ampere per sq.in., and reducing the time of electrolysis to 3 hr.

The specimens austenitized at the higher temperatures tended to "peel" during the electrolysis — particles of steel would flake off the anode. Since the steel particles were magnetic and the carbides nonmagnetic, the two could be separated at the end of the run. It has been demonstrated that this technique is quantitative and reproducible. After separation, the carbides were filtered, washed, dried, weighed and subjected to chemical and X-ray analysis.

The extracted aggregates consisted of mixtures of the carbide phases, and no method was found for separating the individual species. Hence, the weight percentages of the three carbides are not available to match their volume percentages; such a comparison can only be made with respect to the total carbide.

When the carbide residues were chemically analyzed, the sum of C, Fe, W, Mo, Cr, V and (if present) Co approximated 100% only for the annealed steels.* The total for the hardened steels decreased progressively with increasing austenitizing temperature, reaching as little as 82%. This divergence is at least partly due to oxygen, hydrogen, nitrogen (and chlorine from the electrolyte), the contamination becoming more pronounced the higher the austenitizing temperature. Evidently, despite the many precautions employed, side reactions with the electrolyte and during subsequent handling had occurred. Consequently, the measured amounts of the metallic elements in the carbides were prorated upward to adjust their sum to 100%, and the results are plotted in Fig. 3.

In a general way, the tungsten grades contain more carbide by weight than the molybdenum-bearing grades, as might be anticipated, since the atomic weight of tungsten is about twice that of molybdenum. The 12-5-5-5 steel appears to fall in an intermediate category, while the 0-9-4-2 steel has the least carbide. Judging from the tungsten plus molybdenum

*The normal residual elements Mn, Si, S, P, Cu and Ni totaled less than 0.5% in the carbides and were therefore ignored.

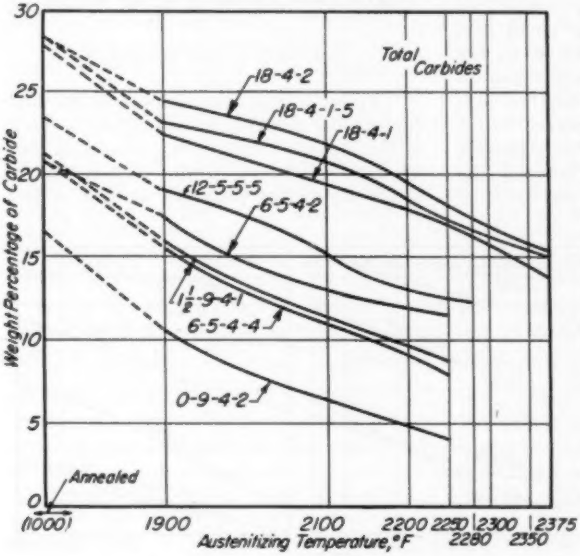
Table III — Weight Versus Volume Percentages of Carbides

Grade	Annealed		Commercially Hardened	
	Weight %	Volume %	Weight %	Volume %
18-4-2 (T-2)	28.5	33.0	15.9	12.0
18-4-1-5 (T-4)	28.6	29.5	15.6	11.2
18-4-1 (T-1)	28.1	29.2	14.8	10.2
12-5-5-5 (T-15)	23.4	32.2	12.4	12.4
6-5-4-2 (M-2)	20.8	28.0	11.8	9.2
1½-9-4-1 (M-1)	21.1	28.9	9.8	9.8
6-5-4-4 (M-4)	20.9	31.9	8.0	9.8
0-9-4-2 (M-10)	16.5	26.0	5.1	6.8

content alone, it might be expected that the 12-5-5-5 curve in Fig. 3 would lie much further above the 6-5-4-2 curve, but the 12-5-5-5 steel contains relatively large fractions of the vanadium-rich carbide MC, which is appreciably less dense than the tungsten-molybdenum-rich carbide M_6C. By the same token, if two steels like 6-5-4-4 and 6-5-4-2 have the same carbide volume (say, after austenitizing at 2225° F., see Fig. 1), the former will have a smaller carbide weight than the latter (Fig. 3), because of the higher proportion of MC.

The eight steels are compared on the basis of both carbide weight and carbide volume in Table III, and are arranged in order of decreasing weight percentage in the commercially hardened condition. In all the annealed steels, the carbide weight percentage is less than the carbide volume percentage. This means that the density of the carbide aggregate is less than that of the steel as a whole. Commercial austenitizing reverses or decreases this difference, signifying that the carbide aggregate increases in density relative to that of the steel. This is caused primarily by the preferential solution of the $M_{23}C_6$ during austenitizing.

Fig. 3 — Weight Percentages of Total Carbides in High Speed After Oil Quenching at Temperatures Indicated



CHEMISTRY OF CARBIDES AND STEEL MATRIX

Compositions of the carbides in the annealed and the commercially austenitized states (oil quenched — O.Q.) are given in Table IV

Table IV — Carbide and Matrix Compositions of the High Speed Steels of Fig. 2

Grade	Carbide Composition							Matrix Composition						
	C	Fe	W	Mo	Cr	V	Co	C	Fe	W	Mo	Cr	V	Co
18-4-1; A.	2.5	25.4	60.7	1.3	7.1	3.2	—	0	95.3	1.5	0.1	3.0	0.2	—
O.Q.	2.1	19.4	73.2	1.4	2.5	1.4	—	0.5	85.3	8.6	0.2	4.4	1.0	—
18-4-2; A.	2.9	22.8	58.5	1.3	8.3	6.3	—	0	95.4	1.8	0.1	2.6	0.3	—
O.Q.	2.8	18.9	70.2	1.3	3.3	3.6	—	0.5	85.3	8.0	0.2	4.4	1.7	—
18-4-1-5; A.	2.6	23.4	59.9	2.6	6.3	3.3	2.0	0	89.0	1.1	0.1	3.4	0.3	6.2
O.Q.	2.6	20.2	70.0	2.5	1.6	1.4	1.6	0.4	79.5	8.3	0.5	4.7	1.1	5.6
12-5-5-5; A.	6.3	15.7	47.2	1.2	7.2	21.2	1.2	0.2	91.4	1.5	0.1	4.2	0.1	2.9
O.Q.	9.1	8.7	47.2	1.4	2.9	29.8	1.0	0.4	81.2	7.3	0.2	5.1	1.4	4.3
0-9-4-2; A.	5.5	28.2	—	44.5	11.3	10.5	—	0	95.5	—	1.0	2.9	0.4	—
O.Q.	8.0	7.3	—	60.5	5.9	18.3	—	0.5	88.8	—	5.4	4.2	1.1	—
1½-9-4-1; A.	3.9	34.9	7.6	39.9	8.7	5.0	—	0	96.9	0.2	0.3	2.5	0.2	—
O.Q.	3.5	34.5	9.8	45.0	3.0	4.3	—	0.6	89.1	0.9	4.7	3.9	0.9	—
6-5-4-2; A.	4.0	27.9	29.4	22.5	7.7	8.5	—	0	95.5	0.3	0.7	3.3	0.2	—
O.Q.	3.7	23.6	39.7	22.3	2.0	8.8	—	0.5	89.0	2.0	3.0	4.6	1.0	—
6-5-4-4; A.	6.4	21.5	22.3	20.3	9.3	20.2	—	0	95.3	1.0	0.4	3.3	0	—
O.Q.	8.7	11.2	27.5	20.4	3.0	29.1	—	0.5	86.1	3.5	3.2	4.7	1.9	—

as corrected for contamination and oxidation of the extracted carbides. Each of the listed compositions totals to 100%, and the usual minor elements are neglected.

These figures, plus the weight percentages in Fig. 3 and the steel compositions in Table I, enable us to compute the compositions of the steel matrix. The resulting values are also listed in Table IV for the annealed and commercially hardened conditions. Figures for carbon in the austenitized steels are uncertain because a small part of the carbon that was dissolved in the martensite-austenite matrix was found to precipitate as free carbon during the electrolysis, thereby raising the apparent carbon content of the extracted carbides. Attempts to distinguish quantitatively between the free and the combined carbon in the residue were unsuccessful. Accordingly, the carbon percentages for the matrices of the austenitized steels may be correspondingly low.

Except for chromium (and cobalt, if present), there is relatively little alloy in the ferritic phase of the annealed steels. Vanadium is usually less than 0.4%. Furthermore, as a result of the carbide solution during commercial austenitizing, the matrix compositions that are listed in Table IV, after quenching from 2200° F. and above, attain fairly uniform levels: 0.4 to 0.6% C, 3.9 to 5.1% Cr and 0.9 to 1.9% V; in addition, the tungsten grades contain 7.3 to 10.3% W, and the molybdenum-bearing grades 5.4 to 6.7% W plus Mo. (These rather close limits are not affected by the cobalt in the 18-4-1-5 and 12-5-5-5 steels, because the cobalt in the matrix appears to substitute for iron, with the sum of the two falling in the range of 85.1 to 89.1%.) The foregoing regularities in matrix compositions after commercial austenitizing account for the similar hardening and tempering characteristics of these high speed steels, notwithstanding their wide variation in over-all composition.

In both annealed and austenitized conditions, the carbides contain larger concentrations of carbon, tungsten, molybdenum and vanadium than does the matrix. The reverse is true for the iron and cobalt. Chromium occupies an intermediate status, being higher in the carbides as-annealed, but higher in the matrix as-austenitized, because of the ready solubility of the $M_{23}C_6$ carbide.

PARTITION OF THE ELEMENTS

Tungsten and molybdenum are the major alloying elements in the carbides because of the dominant M_6C phase. Vanadium also becomes important in the high-vanadium steels due to the enhanced amount of MC

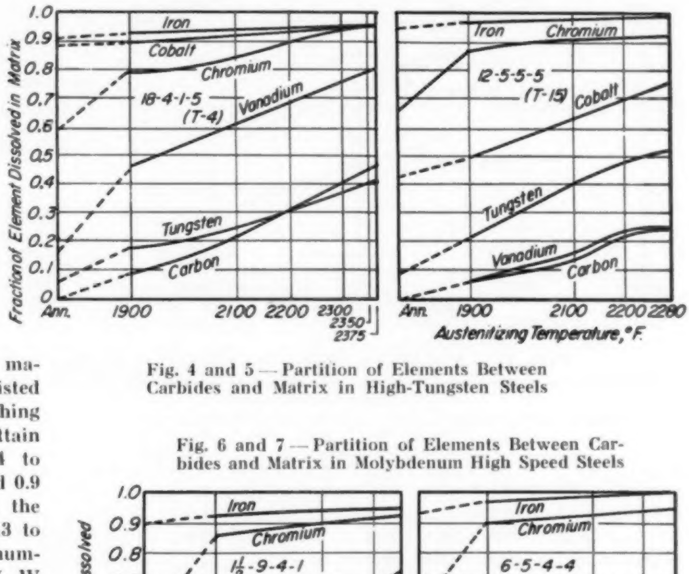
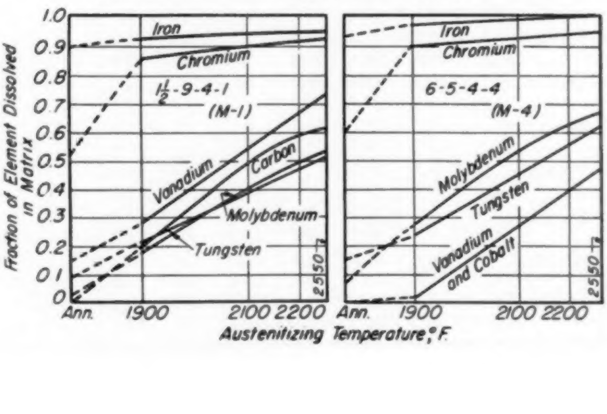


Fig. 4 and 5 — Partition of Elements Between Carbides and Matrix in High-Tungsten Steels

Fig. 6 and 7 — Partition of Elements Between Carbides and Matrix in Molybdenum High Speed Steels



which is found. Carbides in the 12-5-5-5 and 6-5-4-4 steels contain almost 30% V after austenitizing, in contrast to only 1.4% V in the 18-4-1. Despite this spread, the matrices differ by less than 1% in vanadium.

Partition of the elements is shown in Fig. 4 to 7 for four representative steels. The curves for the 18-4-1-5 high-tungsten steel in Fig. 4 are typical of those for 18-4-1 and 18-4-2. Similarly, the curves for the 1½-9-4-1 molybdenum high speed steel in Fig. 6 are typical of those for the 0-9-4-2 and 6-5-4-2 compositions.

In each instance, over half of the chromium in the annealed steel is dissolved in the matrix, and this fraction increases to about 90% in the commercially austenitized condition. Most of the increase occurs with the solution of $M_{23}C_6$ carbide below 1900° F. Tungsten and molybdenum increase in the matrix rather gradually with temperature; roughly half is dissolved after commercial austenitizing. With regard to vanadium, the fraction dissolved depends on the relative amount of MC present. In the low-vanadium steels (Fig. 4 and 6) there is little MC and hence most of the available vanadium dissolves with the M_6C and $M_{23}C_6$ carbides. In the high-vanadium steels (Fig. 5 and 7), a smaller proportion of the available vanadium dissolves because relatively large quantities of the MC carbide are present.

In the 18-4-1-5 steel, some 90% of the cobalt is dissolved in the matrix, and there is little change as a result of austenitizing. On the other hand, in the 12-5-5-5 steel, there is a progressive increase in the fraction of dissolved cobalt from 40 to 70%, indicating that an appreciable part of it exists in the carbides. According to Fig. 5, the trend in dissolved cobalt is more like tungsten than chromium or vanadium, and thus it may be inferred that M_6C is the main source of the additional cobalt that finds its way into the matrix on austenitizing.

SUMMARY

Each of eight grades of high speed steel contains three carbide phases: M_6C a tungsten-molybdenum-rich carbide, $M_{23}C_6$, a chromium-rich carbide, and MC, a vanadium-rich carbide.

As a group, the tungsten grades contain larger percentages of carbides, both by weight and by volume, than do the molybdenum-bearing grades. This is particularly true in the commercially hardened condition. The M_6C carbide usually predominates, but in the high-carbon, high-vanadium types the volume percentage of the MC carbide may equal or exceed M_6C. All the annealed steels contain about 10% $M_{23}C_6$ by volume, but this goes into solution well below the usual hardening temperatures. M_6C and MC dissolve partially during commercial austenitizing. All the steels dissolve practically the same quantity of each carbide, despite substantial variations in the amounts that remain undissolved after hardening. Commercially hardened 18-4-1 (T-1) contains about 10% M_6C and 0.3% MC by volume, while, at the other end of the scale, 12-5-5-5 (T-15) contains about 4% M_6C and 8% MC by volume.

Except for chromium (and cobalt, if present), the bulk of the alloying elements in the annealed steels occurs in the carbide phases. In each instance, over half of the chromium is dissolved in the matrix, and this fraction increases to about 90% in the commercially austenitized condition concomitant with the ready solution of the $M_{23}C_6$ carbide. Roughly half of the tungsten and molybdenum is dissolved in the matrix during commercial austenitizing. The fraction of the vanadium that dissolves ranges through wide limits, being relatively large if only little MC is present and decreasing with increasing amounts of MC. About 90% of the cobalt in the 18-4-1-5 (T-4) steel is dissolved in the matrix, both as-annealed and as-austenitized, but in the 12-5-5-5 (T-15) steel, an appreciable portion stays in the carbides.

Notwithstanding the wide variation in steel composition, the austenite-martensite matrices attain almost the same composition as a result of commercial austenitizing: 0.4 to 0.6% C, 7.3 to 10.3% W (in the tungsten grades), 5.4 to 6.7% W plus Mo (in the molybdenum-bearing grades), 3.9 to 5.1% Cr, and 0.9 to 1.9% V. Cobalt (when present) appears to substitute for iron in the matrix, the sum of the two lying between approximately 85 and 89%, which are the iron limits of the other steel matrices. The foregoing similarities in matrix compositions after commercial austenitizing account for the generally similar hardening and tempering characteristics of these high speed steels.

A Page for Our Biographical Dictionary

Alexander H. D'Arcambal

Vice-President of Pratt & Whitney Div.

An Eminent Living Metallurgist

Time was when Alexander H. d'Arcambal found it expedient to maintain five different identities. This way of life is caused partly by the number of jobs he held simultaneously at Pratt & Whitney and partly by an understandable confusion in the public mind. It's a little complicated, but here goes:

In the early 1940's he held no less than three distinct jobs at P. & W.: sales manager of the small tool and gage divisions; consulting metallurgist to the company; finally, vice-president. When d'Arcambal was traveling about the country, which he did (and does) frequently, he carried three sets of business cards, each stowed in a separate pocket. These cards mix his jobs up in such a way that he could get any combination he wanted. One card described him as "vice-president and sales manager", another card proclaimed "vice-president and consulting metallurgist", while the third had only the chaste title of "vice-president". Aside from the gentle ribbing he took from his friends, there is always the chance that someday somebody would go through his pockets and conclude that he had caught up with a well-equipped confidence man.

Whenever d'Arcambal makes a business call in his capacity of sales manager, he sometimes finds himself being politely excluded from technical discussions "because", the engineers indulgently explain, "as a salesman you naturally won't understand the technical viewpoint". On the other hand, when he attends a meeting in his capacity of metallurgist, the customer's sales people sometimes try to by-pass him when the talk turns to selling problems, since, being a metallurgist and therefore a savant, he couldn't be expected to grasp the delicate nuances of sales techniques. These incidents, which are based on the popular belief in business that an expert in one subject couldn't and shouldn't know anything outside of his special field, might irk a self-important man, but it merely delights d'Arcambal, who can make his weight felt without ever losing his amiable and unperturbed manner. It is not quite clear to this biographer under just what circumstances d'Arcambal uses the cards that merely describe him as a vice-president, but presumably they are reserved for unclassified emergencies, such as laying cornerstones or addressing P.T.A. meetings.

The two remaining identities arise from a most confusing and unscientific situation in Hartford, where there are two separate companies that use the name Pratt & Whitney. D'Arcambal's firm is 90 years old, makes machine tools, small tools and gages, and is a division of the Niles-Bement-Pond Co. The other Pratt & Whitney makes airplane engines and though it was organized under the auspices of the original Pratt & Whitney it has long since separated and is a division of United Aircraft Corp. But many fellow members of the A.S.M. don't know these facts, and look upon d'Arcambal as a specialist in airplane motors.

Even since the War this widespread misconception has sometimes been of great assistance in his travels. Take the time when he found himself unable to get a hotel room in one of our large cities. The room clerk had once worked as a timekeeper in a plant that made P. & W. engine parts, and became quite friendly. Said he had always wondered just how those big P. & W. engines worked. D'Arcambal, who knows a cue when he hears one, proceeded to praise the splendid P. & W. engines. Result — a beautiful outside room with bath.

The name d'Arcambal is French and rather unusual in this country. It causes a great deal of trouble to telephone operators, bellboys, and toastmasters who often settle on the word "archangel". His friends contract it to "Dark".

D'Arcambal was born in Kalamazoo, Mich., on Jan. 23, 1890, and was christened Alexander Harrington. His grandfather came from Chateau-Thierry in France in the middle 1800's and settled in Kalamazoo, possibly a little nervous, at first, living in a town with a name like that. When d'Arcambal was six his family moved to Detroit, where he lived for the next 22 years. In 1908 he entered the University of Michigan and graduated in 1912 with the degree of Bachelor of Chemical Engineering. In 1949 he received the degree of Metallurgical Engineer.

His first plan on leaving college was to specialize in the field of nonferrous metallurgy, and to this end he worked with the Detroit Copper & Brass Rolling Mills, both in the chemical lab and in the rod mill. After about a year, however, he became "intrigued", as he puts it, with the rising automobile industry and decided to forego his nonferrous career. In 1913, then, he went with the Chalmers Motor Co. in Detroit as chemist

An Eminent Living Metallurgist

and assistant metallurgist. This job barely lasted a year, for Chalmers went out of business in late 1914 and d'Arcambal had the good fortune to get a job with Dodge Brothers. Here he became chief chemist under the one and only F. E. McCleary — thus joining that group of engineers who consider "Mac" the man who gave them a real start toward success.

In 1917, Wright-Martin Aircraft Corp. got him to come to the plant in New Brunswick, N. J., where Hispano-Suiza engines were being built for the Allies, and there d'Arcambal was chief metallurgist at the age of 28. When the war was over d'Arcambal felt — as most people did in 1919 — that the aircraft business was a war baby and would be a dead-end in peacetime. He cheerfully admits today that his guess was a bad one. However, the point is an academic one, for d'Arcambal accepted an offer to come to Pratt & Whitney and has had no regrets.

When he joined P. & W., its metallurgical equipment was not very elaborate. His first task was to organize a good department and then run it. In 1927, he was made sales manager of the small tool and gage division in addition to carrying out his metallurgical assignment, and more recently he became a vice-president. In 1950 he was named general sales manager, consulting metallurgist and director of the company.

"Dark" has come to be called "The Great Investigator" by his associates. This nickname arises from his practice of carefully testing every new metallurgical theory that is seriously advanced. For example, he devoted much time, both in laboratory and in plant, to subzero treatment on high speed steel cutting tools, concluding that tools properly heat treated did not need cold treatment. (Pratt & Whitney sponsored the high drawing treatment and multiple high drawing treatments for all high speed steel cutting tools some 30 years ago, which are now common practice.) Another study was on high speed steel cutting tools treated so as to have a considerable percentage of bainite. Cutting tools made of sintered tungsten carbide were produced. Nitriding was adopted for some types of cutting tools over 20 years ago. D'Arcambal admits gracefully that a few of his ideas haven't worked out.

A great deal of d'Arcambal's time is spent in visiting the many chapters of the several technical societies to which he belongs. He estimates that he has delivered at least 200 lectures before chapters of the A.S.M. alone, and served as its national president in 1932. Nowadays, he has cut down on this pace and gives only a few talks a year, mostly on toolsteels, the machinability of metals, and on materials for cutting tools and gages. He is also active in the American Society of Tool Engineers, of which he was national president in 1940.

In the latter part of 1945 he took time off to be scientific consultant of the Technical Industrial Intelligence Committee of the U. S. Foreign Economic Administration, and spent several weeks in Germany studying plants making cutting tools and gages. For this he received a Certificate of Appreciation from the Department of the Army during 1951. In general, he found that most of the tool plants in West Germany were undamaged; that the industry suffered from a severe shortage of alloys, their high speed steel during the latter part of the war containing only 3% tungsten. Their metallurgical and research laboratories were not comparable with those found in the tool and gage plants in this country.

D'Arcambal married Vera Hathaway of Ovid, Mich., in 1918, and has two children and two grandchildren. Son Tom, when getting ready to enter Michigan to study metallurgy, operated with father a small lab in the basement, where they happily produced smells and minor explosions. In 1951 he enlisted in Army Officers Candidate School.

D'Arcambal likes to fish and spends his vacations on Long Island Sound trying to get bluefish to attach themselves to his hook. He is still trying to break 100 in golf. More than anything he likes poker. He actually tries to bluff in a "game" called seven-card stud, high-low, deuces and sevens wild!

D'Arcambal, who received one of Michigan's rarely given citations in 1940 for his work on toolsteels and gage materials, believes that a few years of peace will see a tremendous increase in the use of new and better steels as well as in new applications of cemented carbides. He is still being asked about those Pratt & Whitney engines and continues patiently to explain that his company manufactures machine tools, precision cutting tools and gages, and not aircraft engines. Perhaps a printed card bearing this statement would save his vocal chords.

E. C. McDowell, Jr.

A Small Section of Atomic Research

THE OTHER MORNING while at breakfast in the handsome and modernistic cafeteria at Argonne National Laboratory, the Editor observed through a broad expanse of discreetly curtained glass a continuous stream of buses and automobiles bringing the staff to work. These 3000 people would lift the Laboratory into an entirely different category from the conventional department or institution of that name, even if it were not for the quonsets and permanent buildings spread over 3700 acres of rolling parkland near Chicago. Argonne is the descendant of University of Chicago's "Metallurgical Laboratory" which was organized under that mystifying code name in the early days of the Manhattan Engineer District (atomic bomb project) to verify the theoretical possibility of a chain reaction, and to devise chemical means of separating the reaction products. In keeping with the vastly expanded effort of today's atomic energy program the Laboratory's prime task is now to study all aspects of chain reactors, to find out as much as possible about the essential uranium and the moderators, as well as all supplementary materials that go into the structure, the cooling equipment, the control devices and instrumentation, and the disposal of waste products. This work serves not only the huge static reactors at Hanford for the manufacture of plutonium, but includes the design and study of materials for power reactors of all sorts, for breeder reactors wherein fissionable material is produced more rapidly than it is used up, and small experimental reactors for independent research organizations. Much of this work and its results are classified — that is, hid from foreigners and Americans — even those studies which lead to the generation of useful power rather than the manufacture of bomb-stuff, because the power plants now getting most attention are those allied to weapons, namely for submarines and long-range aircraft, and weapons are top, top secret.

The Metallurgy Division, headed by Frank G. Foote ⊕ and his associate James F. Schumar ⊕, has some 40 researchers of professional status and about the same number of assistants and technicians, with need for about 25% more. Their three major lines of activity may be mentioned. In one, methods for melting, casting, and the hot and cold working of uranium and the other little known metals for reactor construction are studied in a pilot plant generously furnished with standard mill equipment as well as special electric furnaces for melting and casting either in high vacuum or under any protective gas. Another major activity studies the physical constants, mechanical properties, metallography and physical metallurgy of these metals. The third branch includes the design, construction and operation of special test equipment for simulating (under closest control) those unapproachable conditions which exist within reactors. Another closely related department in an even larger building is equipped to investigate the corrosion resistance of the special materials under water at highest temperatures and pressures, and attack by liquid metals suitable for heat transfer mediums in power reactors — all in devices which have not the faintest resemblance to conventional salt spray cabinets or weather machines.

Critical Points

BY THE EDITOR

Forty persons under F. R. Shonka in the Instrument Research and Development Division have made amazing progress in improving, simplifying and miniaturizing radiation counters and dosimeters. Clear plastics have largely replaced glass for the optical systems; two accurately molded pieces merely slipped into a tube replace four glass lenses painstakingly mounted and collimated. To mold an optical surface requires steel dies polished so highly that superfinish is rough, and injection pressures hundreds of times that suitable for, say, a hair comb. (SLOW-MOTION NOTE: The armed forces have not yet accepted these simplified optical systems in hundreds of thousands of fire control and other optical devices, because the plastic scratches more easily than glass and because the plastic glass substitute does not satisfactorily resist

high-temperature storage, although it is actually far better in that respect to the plastic already in the mountings for the glass lenses.)

Happily a very considerable effort is expended toward more beneficent aspects of atomic energy. About 250 people (of whom over a hundred are of professional status) are investigating biological and medical aspects of radiation as well as health and industrial hygiene. A fascinating place shown by N. J. Scully of the Plant Physiology Group contains several small glass houses where foxglove and poppies are being grown in an atmosphere containing radioactive CO_2 and therefore forced to produce "tagged" digitalis, morphine and codeine in their natural life process. These drugs, with radioactive carbon built right into the organic molecule, advertise their presence to proper counters, and for the first time in medical history their exact location — whether in heart muscle, blood stream, brain or nervous system — is being plotted and the proportion determined which is usefully retained or wastefully excreted.

Martempering and Slack Quenching

THE EDITOR, as a side issue from his somewhat standardized talk on atomic energy before the Lehigh Valley Chapter, visited Ingersoll-Rand's plant in Phillipsburg, N. J., in company with ⊕ Past-President Shepherd, where such a variety of sturdy machinery is manufactured — rock drills, air compressors, pumps, condensers, refrigeration equipment, it is almost "a glorified jobbing shop", in Shepherd's words. (His name, by the way, is Benjamin Franklin Shepherd, and he responds readily to either "Ben" or "Frank"; even though the middle name is preferred by his home-town folks, it is pretty hard to think of him as "B. Franklin Shepherd"!)

Frank (or Ben) toured occupied Germany shortly after the end of World War II to investigate the metallurgical practices in enemy plants manufacturing mining and quarrying equipment and discovered that we in America were far ahead of them in applying special analyses to special duties. Their practice was about the same as ours is today in the field of deep drawing sheet; the Germans would order metal, say, for a pump shaft of such and such size to handle such and such liquid, and the steel mill would send some bars, often without identification except in most general terms. Such a situation, where machinery Firm A had no chance to gain competitive advantage over Firm B by improved metallurgical engineering, was particularly baffling to a man like Shepherd who received the ⊕ Sauveur Achievement Award in 1941 for devising methods for evaluating those elusive factors that comprise "body" or "quality" in toolsteel — magic words for steel salesmen years ago when he started his life work of making rugged rock drill machinery even tougher, more reliable, and more manageable. Some of the well-known results are his fracture grain size standards, his P-F test for measuring the hardenability of shallow hardening carbon steels, and his accurate control of the traditional "slack quenching" eventually resulting in the process that has been dubbed "martempering".

At Ingersoll-Rand, by the way, the quenching fluid for martempering is molten salt. Slack or interrupted quenching is done in 10% brine recirculated constantly so it comes to the quench at constant temperature; volume of flow is controlled by Venturi meters in each supply line; quenching is done in a rising column of brine in a pipe of proper size, supplemented if necessary by individual jets directed against certain conformations or inside holes. Quenching is piece by piece; duration is controlled by an accurate timer, pre-set for the job in hand. (Some small sections of toolsteel are in the quench as little as 2 sec.; they are file hard about an hour later when they reach room temperature.) All operations in this heat treatment department are under instrumental control of the recording type. Ben is especially proud of the fact that accurate martempering, which hardens intricately machined parts with vanishing distortion, was demonstrated before ordnance officers and used widely during World War II for M66 fuse parts. In one Pittsburgh shop, for example, there was not a single rejection for oversize or softness in 400,000 pieces.

Practice at Ingersoll-Rand is by no means static. For example, a new complicated job, requiring localized hardening on opposite wings, is done by oxy-acetylene

flame — an old process, indeed, but not so commonly used for mass production. "The men in the shop are pretty open minded," said Ben, "but they had so many doubts about this scheme that we developed the machine and the routine over in the laboratory building. When it was working smoothly and giving us the desired results, we brought the shop foremen over and asked them to take a look, and they said without further argument that if the boys in the laboratory could do it, the men in the shop certainly could."

Basic Lining for Cupolas

Revisited the large Birmingham foundry of American Cast Iron Pipe Co. after seven years and found the metallurgical staff (as of old) energetically pursuing new ideas. In one corner thousands of T-head bolts for pipe joints are cast daily in permanent molds; the bolts are of fast-annealing malleable; the iron is melted in a small water-cooled cupola; the whole operation warrants the full description promised by Chas. Donoho, chief metallurgist.

Most of my time was used in discussing basic linings for cupolas with Sam Carter, assistant melting superintendent for American Cast Iron Pipe Co. (and currently chairman of Birmingham Chapter ⊛). Their work with such linings dates back at least five years, and many commercial refractories, both brick and granular, American and imported, have been tried, with the conclusion that American dolomite is best when gunned onto magnesite brick as repairs are needed. Costs for such basic linings are higher (on the order of $1 per ton of iron melted) than for conventional acid linings but, in Carter's opinion, the extra expense is easily repaid under certain circumstances.

For example — suppose the foundry wants to cast low-sulphur iron, malleable as-cast ("nodular iron"). A slag very similar to the second slag in a basic electric furnace can be run and a charge normally melting to 0.10% S will melt to 0.03%. Or, as another example, suppose the foundry has a high percentage of sprues and other remelt to handle, and the coke is none too low in sulphur; then the iron will creep up gradually in sulphur, bringing in its train all kinds of troubles.

Another important application of the basic cupola is for melting high-steel charges in those localities where steel scrap is cheaper or more available than pig iron. Such a charge must be greatly carburized during melting — a difficult thing to do in an acid cupola. Carter thinks that acid slags "wet" hot coke, spreading over it and preventing it from coming into that physical contact with hot iron so necessary for its carburization into gray cast iron. The higher sulphur contents of iron melted in acid linings will also tend to lower the solubility of carbon.

Basic linings are fine, also, for retaining valuable alloys. As an example, this plant is called upon to make die-pot liners for shell forging. Worn-out pots of this Ni-Mo-Cr cast iron go around and around in a circle from foundry to forge plant and back to foundry. Only a limited proportion can be added to the charge in the acid cupola, but the basic cupola can remelt as much as 100% return so successfully that only a little chromium is needed as a sweetener. Furthermore, the sulphur is kept so low that little or no counteracting manganese is needed in most irons. Such conservation of scarce alloys and a balanced utilization of materials of marginal quality are matters of importance in critical times such as these.

It would seem that basic cupolas would be just right for gray iron foundries in certain regions where steel scrap is cheaper than pig iron or where good low-sulphur coke demands an unusual premium. Even where such conditions do not exist, large jobbing foundries would find it very handy if at least one of their cupolas were basic lined; it could then be used to handle many a special order both economically and neatly.

An Improved Cell for Electrolytic Polishing

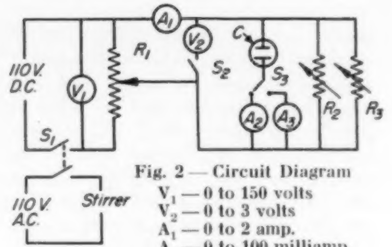


Fig. 2 — Circuit Diagram
V_1 — 0 to 150 volts
V_2 — 0 to 3 volts
A_1 — 0 to 2 amp.
A_2 — 0 to 100 milliamp.
A_3 — 0 to 500 milliamp.
R_1 — 42 ohms, 2 amp.
R_2 — 10 ohms
R_3 — 20 ohms
S_1 — DPST toggle
S_2 — SPST toggle
S_3 — Two-position rotary

An easily constructed, inexpensive and widely useful cell for the electrolytic polishing and etching of metallographic specimens is shown in Fig. 1. The cell is made from a 2½-in. length of lucite tubing, 2 in. inside diameter with $\frac{1}{16}$-in. wall. The ends of this tube are closed with polystyrene plugs, the top with a bushing for a motor-driven stirrer. The sample is mounted in a 1-in. plastic cylinder. A 1-in. opening is bored in the side of the cell for insertion of the mount. The cathode, which can be of graphite, is mounted on an 8/32-in. screw which enters the cell directly opposite the opening for the mount. This screw serves both as the electrical contact and a means of varying the cathode-anode distance. An opening is provided in the bottom of the cell for the introduction of the electrolyte from a leveling bottle. Electrical contact to the metal specimen is made by drilling and tapping a hole in the side of the plastic mount and inserting a screw, either with or without mercury. The contact side of the mount is chosen for least interference with subsequent microscopic examination.

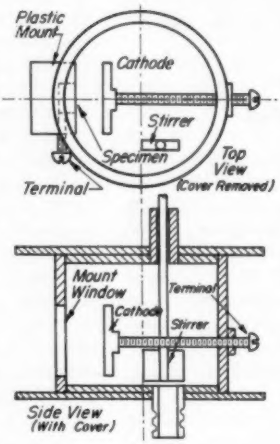


Fig. 1 — Cell for Electrolytic Polishing and Etching

Figure 2 is a schematic diagram of the circuit. It is a modification of that used at the U. S. Naval Gun Factory, described in *Metal Progress* for February 1947, p. 263.

This cell is not suitable for electrolytes which contain perchloric acid, but is widely useful for other acid electrolytes. It has definite temperature limitations but can be used for work up to about 160° F. by preheating the electrolyte.

The equipment was put to good advantage in the electrolytic polishing of 14-carat gold. The electrolyte originally consisted of 0.5% $AuCl_3$ solution plus 10% KCN, but investigation led to the conclusion that dilute HCl plus 10% KCN worked just as well.

Tests were run to determine the effect on the microstructure of such variables as electrolyte composition, cell voltage and current, previous mechanical polish, cathode-anode distance, rate of agitation, time of current flow, and cathode material, varying each independently and holding all other factors constant. The anode area was constant in all runs at 0.094 sq.in.

Electrolyte Composition, Cell Current and Cell Voltage are correlated in Fig. 3. Each point represents a determination on a given sample of gold alloy, previously polished with 00 paper. Carbon cathode was set ⅜ in. from the sample, and rate of agitation was 700 r.p.m. Time of current flow was 1 min. The cell conditions that gave the best polishing and etching for any electro-

By **L. W. Gleekman,** Assistant Professor in Chemical Engineering, University of Delaware
G. E. Evans, Physicist, Oak Ridge National Laboratory
and **C. S. Grove, Jr.,** Professor of Chemical Engineering, Syracuse University

Professor Gleekman was formerly a graduate student, Dr. Evans was assistant professor of chemistry, and Professor Grove was head of the division of chemical engineering at State University of Iowa, Iowa City.

lyte composition were along the isocurrent lines (where a change in voltage produced no change in current). This agrees with Kehl's statement for electrolytic polishing and etching in general in "Principles of Metallographic Laboratory Practice", p. 28. It was also found that the alkalinity of the electrolyte (as measured by the pH) increases as a given electrolyte is used continuously for polishing and etching. This indicates that HCN was being driven off, and adequate ventilation must be provided.

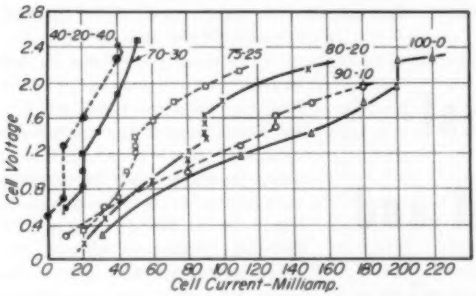


Fig. 3 — Cell Current and Voltage for Various Electrolyte Compositions. First number in the electrolyte designation indicates cc. of 10% KCN; second number is dilute HCl, and third number the amount of water

Previous Mechanical Polish coarser than 0 paper gave a polished and etched surface with a large number of scratches under fixed cell conditions. Finer papers had no visible effect on final microstructure.

Increasing the Cathode-Anode Distance from ¼ to ¾ in. in ⅛-in. increments had no noticeable influence on final surface.

Rate of Agitation — With no agitation or stirring, a dark film formed on the sample, resulting in neither a polish nor an etch. This film had an appreciable electrical resistance, as shown by the fact that the current was 20 milliamp. at 1.50 volts. At 100 r.p.m. the polish was poor and streaky and the current was 40 milliamp. At 400 r.p.m. a poor but slight etch formed — current was 60 milliamp. Agitation at 700 and at 900 r.p.m. gave a fine polished and etched surface in 1 min. at 80 and 90 milliamp., respectively. With 1300 r.p.m. there was no change in cell characteristics but the etch was streaked and quite spotty. The cell current was still 90 milliamp.

Electrolytic Polishing Variables

Current Flow — At least 30 sec. was required to give a good etch under the best fixed conditions previously determined. In 15 sec. there was no etch and only a slight polish. Up to 1½ min. no great change appeared in the microstructure except a tendency toward darkening. This tendency was definitely noticeable for a flow of 2 min.

Cathode Material — Polishing and etching of gold samples was as successful with a graphite cathode as with a gold cathode. Best results were obtained with the graphite when it was cleaned at least every other day in aqua regia and then distilled water.

Micrographs of 14-carat gold polished and etched under optimum conditions are shown in Fig. 4. The samples were 0.025 in. thick, and were mounted side by side so that all etched simultaneously. Each had been heat treated at different recrystallizing temperatures, and the grain sizes obtained did not have identical etching characteristics. A noticeable edge effect is apparent at the gap between adjacent specimens.

A cell of this same design was used successfully to etch copper, brass, steel, cast iron and stainless steel. The electrolyte was 10% (by weight) of chromic acid with 3 drops of 20% H_2SO_4. Increasing the temperature of the electrolyte by prior heating (in certain runs to a maximum of 165° F.) resulted in shorter time for polishing and etching, but the microstructure was not as sharp and well-defined as for runs at room temperature. Use of 2% nital as an electrolyte is not desirable, since it attacks the lucite cell and causes crazing.

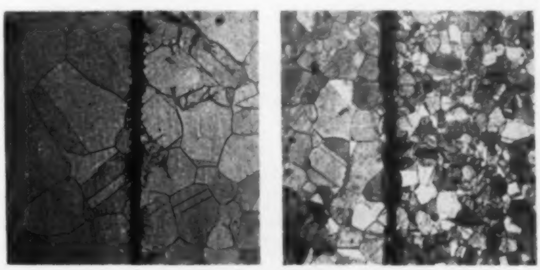


Fig. 4 — Four Samples of 14-Carat Gold of Varying Grain Size Mounted Side by Side and Etched Simultaneously. 75 ×

Fast Cutting of Metal by Better Mechanical and Metallurgical Engineering

By Metal Progress' Special Reporter

THERE IS AN active Council of Technical Societies in New Jersey and once a year it holds a general conference on current matters of importance. This year the event was held in Newark, and half of the time was given to a panel discussion of machinability under chairmanship of Norman L. Woldman ⊕, consulting metallurgical engineer.

The cutting of metals by machine-driven tools is, of course, the traditional (and the usual) method, and a vast amount of work has been done in the last century on toolsteels and tool materials — the tool itself, its shape and lubricant, the relationship between tool and material being cut, and the machinery for doing the work. Hans Ernst ⊕, director of research for Cincinnati Milling Machine Co., presented some remarks on the last-mentioned item, emphasizing the use of servomechanisms for contour milling and for handling the enormous machines demanded by the aircraft and heavy mill equipment industries.

He then discussed the intriguing question of temperature in relation to machinability, especially as it affects tool life (amount of metal cut before regrinding is necessary) — which in his opinion is important from an economic standpoint.

"It is evident", said Dr. Ernst, "that tool wear is caused by the abrading action of the chip and the workpiece upon the face and flank of the tool. This involves the effect of two opposing factors: the ability of the chip to abrade the tool, and the ability of the tool to withstand abrasion. As the temperature of the work material is increased, its ability to abrade the tool and the force exerted against the tool are both decreased; but if the temperature of the tool increases, its ability to withstand this abrasion is decreased. Hence the rate of wear for any given condition depends on the relative value of these two abilities. Actually, however, the temperature of the tool may be lowered as we raise the temperature of the workpiece, because of the lower force exerted by the material against the tool and the consequent lesser work done against friction on the tool face."

The general problem of "hot cutting" was discussed in *Metal Progress* for June 1951 (p. 793). Dr. Ernst showed figures to indicate that there is an optimum temperature for the workpiece; experimentally this has been found to be 500° F. for 16-25-6 Cr-Ni-Mo Timken alloy. For other materials the optimum temperature may be either above or below room temperature; in some instances it may be even above 1500° F.

Looking in the other direction, he described his experimental setup (Fig. 1) for studying the effect of refrigerating the tool. Of course it has long been known, or assumed, that the cutting fluid has two basic functions — cooling the tool and reducing the friction between tool and chip. Just how the second function could operate, in view of pressures up to 50,000 psi. exerted by the tool face, was not usually explained. Nevertheless, the success of high-velocity jets of lubricants shot up from below and entering the working relief angle has recently been commented on in "Critical Points" (March issue); this scheme certainly puts the cutting oil where it is needed, and it also appears to multiply high speed tool life on common steels by a factor of 6 to 12.

Reverting to real refrigeration — as by dry ice — the idea is to cool the tool without cooling the work and thereby increasing its shear strength. Dr. Ernst said that "so far as is now known, the only function which CO_2 can perform is to cool the tool. There is as yet no evidence to indicate that it acts in any way to reduce the friction.

"Its use is still experimental and the results obtained have varied widely. On

materials which are very difficult to machine (such as the English jet engine material Nimonic) it increases tool life and cutting speeds of certain grades of carbides. In other trials no benefit has been obtained."

Erosion on Tool — A corridor Gossip disagreed with some of the postulates advanced by Dr. Ernst (and this reporter could not but wish that the American engineering *audience* was less inhibited and more argumentative). He thought there was experimental evidence to show that tool erosion is akin to fretting — that is, caused by cold welding of chip to tool face — and the pressures are so high that lubrication as we ordinarily think of the term is impossible.

"What then is the function of the oil?"

"A coolant. It is superior to a water jet principally because it wets better and therefore there is a higher heat transfer rate." Mr. Gossip opined that carbides are better than high speed principally because of the high resistance to erosion, and some day he said he was going to try a tool with siliconized surface because it has a low coefficient of friction against carbon steel (and this would generate less heat and possibly reduce the rate of cold welding). Likewise, he believed there is a good opportunity for increasing life of carbide tools an important fraction by improving the rigidity of the entire machine tool, lathe, milling machine, or whatever, and so reducing destructive vibrations at the cutting edge.

SELECTION OF CARBIDE CUTTERS

Chief Engineer Malcolm F. Judkins ⊕, of Firth-Sterling Steel Co., McKeesport, Pa., gave an interesting résumé of the six causes of carbide tool failure, and their probable cure. His remarks may be reduced to an outline:

1. Breakage

(a) From excessive pressure: Reduce cutting pressure by reducing feed and increasing speed proportionately to maintain desired production rate.

(b) From inadequate size of tool or insufficient support: Use a larger, better supported tool.

(c) Improper design: Enlarge chip control groove; grind a more generous shoulder fillet radius; try a tool having a negative rake or negative rake land along the edge; try a side-cutting edge angle design if feasible.

(d) Faulty brazing or grinding: Use shim braze; correct grinding practice by using a coarse, open wheel for roughing (wet) and a diamond wheel for finishing.

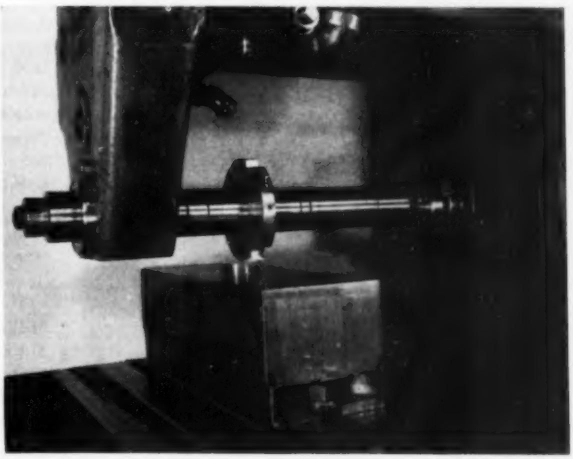
(e) Improper application: Instruct operator in proper techniques; hone cutting edge very slightly to stop chipping; disengage feed before stopping machine; make certain tool is set on center.

(f) Wrong grade: As a last resort after exhausting all other possibilities, substitute a stronger grade with either a coarser grain or higher cobalt.

2. Edge or flank wear. Premature edge or flank wear can usually be corrected by decreasing the speed and increasing the feed proportionately to maintain desired production rate; improving the edge and face finish grinding and honing; better rake and relief; use of a more wear resistant grade with finer grain size, lower content of cobalt or higher titanium carbide.

3. Crater or face wear. Excessive crater or face wear can be reduced by reducing the feed and increasing the speed; using a positive rake and polished tool face; effective cutting fluid; use of a composition with

Fig. 1 — Experimental Rig for Spraying Liquid CO_2 on the Face of a Single Milling Cutter Tooth Through Passages Cut in Arbor and Cutter. Note spray from jet and coating of dry ice on tool face. (Cincinnati Milling Machine Co.)



higher tantalum and titanium and lower cobalt content.

4. Heat. If heat is causing early failure either through softening and mushrooming of the tip or because of thermal cracks, try changing the feed-speed combination to get cooler cutting. Use positive rake and ample relief and flood the tool with coolant at all times, or switch to a grade with lower cobalt and higher titanium-tantalum carbide.

5. Pitting or adhesion of the chips upon the tool face. This can usually be prevented by increasing the cutting speed, decreasing the feed, polishing the tool face and using positive rakes; or, use a grade with higher Ta-Ti carbide and lower cobalt.

6. A combination of two or more of the preceding.

MICROSTRUCTURE VERSUS MACHINABILITY

Late in 1948 the U. S. Air Force organized a committee to study machinability of steels, irons and jet alloys used in the mobilization program with R. T. Hurley, president of Curtiss-Wright Corp., Wood-Ridge, N. J., as chairman. Later an extensive test program started at Ford Motor Co., of Dearborn, Mich., Metcut Research Associates of Cincinnati, Massachusetts Institute of Technology of Cambridge, and Curtiss-Wright. Two beautiful small volumes containing the findings have been published under title of "Increased Production and Reduced Costs Through a Better Understanding of the Machining Process and Control of Materials, Tools and Machines". John F. Kahles, partner in Metcut Research Associates, contributed to this panel in Newark a brief discussion of "Microstructure and Machinability", drawing upon the voluminous material in the two volumes above mentioned. Figure 2 is a generalization, accurate to ±10%, of results on two steels of high machinability and the common heat treatable steels 8620, 3140, 4140, E4340, 5140 and 8640, cut by carbide turning and milling tools under standardized conditions. Similar correlation would exist if the cutting tool were a conventional 18-4-1 high speed, although of course the location of the curves on the graph would be different.

(Continued on p. 120)

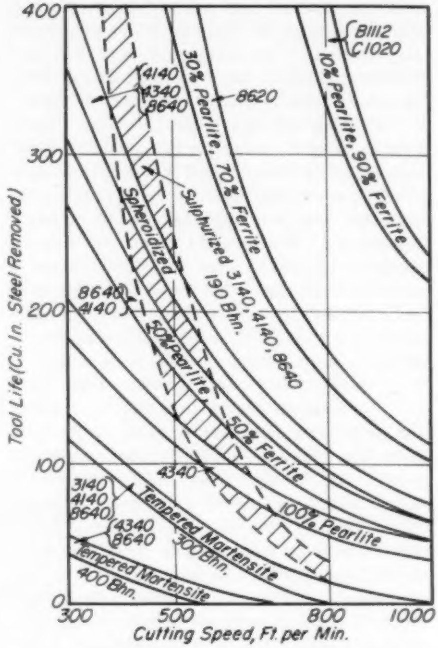
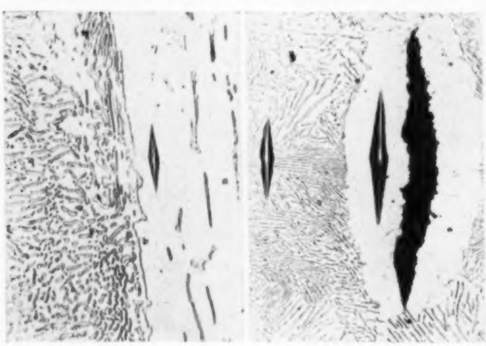


Fig. 2 — General Correlation Between Microstructure, Cutting Speed and Tool Life (Cu.In. of Steel Removed to a Wearland of 0.030 In. on the Clearance Flank) With Various Common Steels Used for Aircraft Parts When Cut With Carbide Tools Without Lubricant Under Standard Conditions:

Feed per revolution	0.010 in.
Depth of cut	0.100 in.
Back rake	0°
Side rake	6°
Side cutting angle	0°
End cutting edge angle	6°
Relief	6°
Nose radius	0.040 in.

Fig. 3 — Left: Carbide Streak in Pearlite; Right: Ferrite Island Surrounding Graphite Flake. Knoop impressions clearly show large difference in hardness of the two clear constituents. 350 ×



Grade	Carbon	Manganese	Nickel	Chromium	Molybdenum	Notes
TS14B35	0.33/0.38	0.75/1.00	—	—	—	2, 4
TS14B50	0.48/0.53	0.75/1.00	—	—	—	5
14B52	0.47/0.55	1.20/1.55	—	—	—	5
TS4012	0.09/0.14	0.75/1.00	—	—	0.15/0.25	1
TS40B32	0.30/0.35	0.70/0.90	—	—	0.08/0.15	2, 4
TS40B37	0.35/0.40	0.70/0.90	—	—	0.08/0.15	3, 4
TS4130	0.28/0.33	0.45/0.65	—	0.90/1.20	0.08/0.15	1
TS4132	0.30/0.35	0.45/0.65	—	0.90/1.20	0.08/0.15	1
TS4135	0.33/0.38	0.75/1.00	—	0.90/1.20	0.08/0.15	1
TS4137	0.35/0.40	0.75/1.00	—	0.90/1.20	0.08/0.15	1
TS4140	0.38/0.43	0.80/1.05	—	0.90/1.20	0.08/0.15	1
TS4142	0.40/0.45	0.80/1.05	—	0.90/1.20	0.08/0.15	1
TS4145	0.43/0.48	0.80/1.05	—	0.90/1.20	0.08/0.15	1
TS4147	0.45/0.50	0.80/1.05	—	0.90/1.20	0.08/0.15	1
TS4150	0.48/0.53	0.80/1.05	—	0.90/1.20	0.08/0.15	1
TS43BV12	0.08/0.13	0.75/1.00	1.65/2.00	0.40/0.60	0.20/0.30	1, 4, 7, 8
TS43BV14	0.10/0.15	0.45/0.65	1.65/2.00	0.40/0.60	0.08/0.15	1, 4, 7
TS46B12	0.10/0.15	0.45/0.65	1.65/2.00	—	0.20/0.30	1, 4
TS4613	0.10/0.15	0.45/0.65	1.65/2.00	—	0.25/0.35	1
TS4618	0.15/0.20	0.45/0.65	1.65/2.00	—	0.25/0.35	1
TS4720	0.17/0.22	0.50/0.70	0.90/1.20	0.35/0.55	0.15/0.25	1
50B15	0.12/0.18	0.70/1.00	—	0.35/0.60	—	5
50B20	0.17/0.23	0.70/1.00	—	0.35/0.60	—	5
50B30	0.27/0.34	0.70/1.00	—	0.35/0.60	—	5
50B35	0.32/0.39	0.70/1.00	—	0.35/0.60	—	5
50B37	0.34/0.42	0.70/1.00	—	0.20/0.40	—	3, 4
50B40	0.37/0.45	0.70/1.00	—	0.35/0.60	—	5
50B44	0.42/0.50	0.70/1.00	—	0.35/0.60	—	5
TS50B46	0.43/0.50	0.75/1.00	—	0.20/0.35	—	5
50B49	0.47/0.55	0.70/1.00	—	0.20/0.40	—	5
TS50B50	0.48/0.53	0.75/1.00	—	0.40/0.60	—	5
TS50B60	0.55/0.65	0.75/1.00	—	0.40/0.60	—	5
TS51B60	0.55/0.65	0.75/1.00	—	0.70/0.90	—	5
80B15	0.12/0.18	0.60/0.90	0.20/0.40	0.15/0.35	0.08/0.15	5
80B17	0.14/0.20	0.60/0.90	0.20/0.40	0.15/0.35	0.08/0.15	5
80B20	0.17/0.23	0.60/0.90	0.20/0.40	0.15/0.35	0.08/0.15	5
80B25	0.21/0.28	0.60/0.90	0.20/0.40	0.15/0.35	0.08/0.15	5
80B30	0.27/0.34	0.55/0.80	0.20/0.40	0.15/0.35	0.08/0.15	5
80B35	0.32/0.39	0.65/0.95	0.20/0.40	0.15/0.35	0.08/0.15	5
TS80B37	0.35/0.40	0.75/1.00	0.20/0.40	0.20/0.35	0.08/0.15	3, 4
80B40	0.37/0.45	0.70/1.00	0.20/0.40	0.15/0.35	0.08/0.15	5
80B45	0.42/0.50	0.70/1.00	0.20/0.40	0.15/0.35	0.08/0.15	5
80B50	0.47/0.55	0.70/1.00	0.20/0.40	0.25/0.50	0.08/0.15	5
80B55	0.50/0.60	0.70/1.00	0.20/0.40	0.30/0.55	0.08/0.15	5
80B60	0.55/0.65	0.70/1.00	0.20/0.40	0.30/0.55	0.08/0.15	5
TS8115	0.13/0.18	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8117	0.15/0.20	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8120	0.18/0.23	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8122	0.20/0.25	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8123 (S)	0.20/0.25	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1, 6
TS8125	0.23/0.28	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8126 (S)	0.23/0.28	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1, 6
TS8127	0.25/0.30	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8128 (S)	0.25/0.30	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1, 6
TS8130	0.28/0.33	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8132	0.30/0.35	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8135	0.33/0.38	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1, 2
81B35	0.32/0.39	0.70/1.00	0.20/0.40	0.30/0.55	0.08/0.15	5
TS8137	0.35/0.40	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1, 3
TS8140	0.38/0.43	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS81B40	0.38/0.43	0.75/1.00	0.20/0.40	0.35/0.55	0.08/0.15	5
TS8142	0.40/0.45	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8145	0.43/0.48	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
81B45	0.42/0.50	0.70/1.00	0.20/0.40	0.30/0.55	0.08/0.15	5
TS8147	0.45/0.50	0.70/0.90	0.20/0.40	0.30/0.50	0.08/0.15	1
TS8150	0.48/0.53	0.75/1.00	0.20/0.40	0.35/0.55	0.08/0.15	1
81B50	0.47/0.55	0.75/1.05	0.20/0.40	0.35/0.60	0.08/0.15	5
TS8155	0.51/0.58	0.75/1.00	0.20/0.40	0.35/0.55	0.08/0.15	1
TS8160	0.55/0.62	0.75/1.00	0.20/0.40	0.35/0.55	0.08/0.15	1
TS8165	0.60/0.70	0.75/1.00	0.20/0.40	0.35/0.55	0.08/0.15	1
TS8615	0.13/0.18	0.70/0.90	0.30/0.60	0.55/0.75	0.08/0.15	1
TS8617	0.15/0.20	0.70/0.90	0.30/0.60	0.55/0.75	0.08/0.15	1
TS8620	0.18/0.23	0.70/0.90	0.30/0.60	0.55/0.75	0.08/0.15	1
TS8622	0.20/0.25	0.70/0.90	0.30/0.60	0.55/0.75	0.08/0.15	1
TS8625	0.23/0.28	0.70/0.90	0.30/0.60	0.55/0.75	0.08/0.15	1
TS8627	0.25/0.30	0.70/0.90	0.30/0.60	0.55/0.75	0.08/0.15	1
TS8630	0.28/0.33	0.70/0.90	0.40/0.70	0.55/0.75	0.08/0.15	1
TS8632	0.30/0.35	0.70/0.90	0.40/0.70	0.55/0.75	0.08/0.15	1
TS8635	0.33/0.38	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1
TS8637	0.35/0.40	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1
TS8640	0.38/0.43	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1
TS8641 (S)	0.38/0.43	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1, 6
TS8642	0.40/0.45	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1
TS8645	0.43/0.48	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1
TS86B45	0.43/0.48	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	5
TS8647	0.45/0.50	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1
TS8650	0.48/0.53	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1
TS8653	0.49/0.55	0.75/1.00	0.40/0.70	0.65/0.85	0.08/0.15	1
TS8655	0.50/0.60	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1
TS8660	0.55/0.65	0.75/1.00	0.40/0.70	0.55/0.75	0.08/0.15	1
TS94B15	0.13/0.18	0.75/1.00	0.30/0.60	0.30/0.50	0.08/0.15	5
TS94B17	0.15/0.20	0.75/1.00	0.30/0.60	0.30/0.50	0.08/0.15	5
TS94B20	0.17/0.22	0.75/1.00	0.30/0.60	0.30/0.50	0.08/0.15	5

Boron and Tentative Standard Steels

American Iron and Steel Institute, March 25, 1952

NOTE 1 — An interim alternate (or tentative standard) steel designed to conserve nickel or molybdenum. They apply to hot rolled alloy steels generally not exceeding 200 sq.in. in cross-sectional area, or 18 in. in width, or 10,000 lb. in weight per piece. They also apply to alloy steel wire and to cold finished alloy steel bars.

NOTE 2 — For cold heading and cold forging wires, for making components up to and including ½ in. in diameter. A group of five grades is intended to provide material for a wide range of parts produced from alloy steel wire. For larger components, see NOTE 3.

NOTE 3 — For cold heading and cold forging wires, for making components over ½ in. in diameter and up to ¾ in. A group of four grades is intended to provide material for a wide range of parts produced from alloy steel wire. For smaller components see NOTE 2.

NOTE 4 — Designations with B are boron-treated steels, and can be expected to have 0.0005% min. boron content.

NOTE 5 — Boron-treated steels developed to conserve nickel and molybdenum, and can be expected to have 0.0005% min. boron content. Available as hot rolled alloy steels generally, alloy steel wire, and cold finished alloy steel bars.

NOTE 6 — Sulphur content of TS8123, 8126 and 8128 is 0.035 to 0.050; of TS8641 (S) is 0.040 to 0.060%.

NOTE 7 — Also contains 0.03% min. vanadium.

NOTE 8 — Silicon content is 0.20 to 0.40%.

Notes on Composition

Phosphorus and sulphur limits for each process are:

Basic electric, 0.025% max.

Basic openhearth, 0.04% max.

Acid electric, 0.05% max.

Acid openhearth, 0.05% max.

An exception is TS8641 (S), whose sulphur is 0.040 to 0.060%.

Silicon range for each of the steels listed here is 0.20 to 0.35%, except TS43BV12 (0.20 to 0.40%). For acid openhearth or acid electric, minimum is 0.15%.

Incidental Elements — Small quantities of certain elements are present in alloy steels which are not specified or required. These elements are considered as incidental and may be present to the following maximum amounts: Copper, 0.35%; nickel, 0.25%; chromium, 0.20%; and molybdenum, 0.06%.

METAL PROGRESS
JUNE 1952, PAGE 96-B

By F. P. Zimmerli, Chief Engineer, Barnes-Gibson-Raymond Division
of Associated Spring Corporation, Plymouth, Michigan

Heat Treating, Setting and Shot-Peening of Mechanical Springs*

After getting a good idea of the metal wire and strip ordinarily used for mechanical springs (the subject of the first portion of the 1951 William Park Woodside lecture before the Detroit Chapter ⊕ published in the May issue of *Metal Progress*) the next consideration of the metallurgist could be called "metallurgical operations in spring manufacture".

Naturally, the forming operations are of prime importance. The surface of a spring is the region of highest stress, and the surface is hardly improved when a spring is made. The surface of the spring is the same as the original material plus any tool marks. These marks might be considered as stress raisers, and since there is no machining or grinding to change the surface, it behooves the producer to keep these imperfections to a minimum. The higher the working load per unit area, the more important this is.

Heat Treatment — After forming, all of the springmaker's products are heat treated, even though it is but to relieve strains induced in the forming operation. No matter what physical shape the material may have, only two states are employed, *(a)* soft and *(b)* of at least the hardness desired in the finished product. In the first classification fall annealed steels and some nonferrous alloys which can be hardened by heating. In the second we find all materials whose physical properties depend upon cold work and those which are heat treated to the desired properties before forming.

Best practice is to use materials hardened *before* the spring is fabricated. If it is made from steel, this will eliminate the possibility of hardening cracks because, if they are formed in the original mill treatment, they would open up in forming the spring. Forming from hardened sections gives a better opportunity to locate possible laps or seams in ferrous or nonferrous materials. The second reason for this practice is that nonuniform temper in the material as received from the mill will be shown in uneven recoil from the spring-forming tools, so that parts not metallurgically alike will be detected easily. Lastly, and as a corollary to the above, better fatigue life will result in most instances. This is of great importance where springs are vital to the functioning of a large unit — for instance, valve springs in an engine where uniformity of the product is a paramount consideration.

If material of "spring temper" cannot be used, then soft material is the alternative. The nonferrous metals used are quenched soft and merely reheated, but steel must be hardened and drawn. Several methods are available — namely, ordinary oil quench and draw to the desired hardness, austempering to the same hardness, and martempering by quenching in salt at 425° F. and then drawing to the same hardness. Experience has shown that:

1. Austempered springs do not have the stress range† at equal hardness or tensile strength of springs made by either of the other methods, but have less dimensional change from heat treatment, and should be considered if a lowered stress range is secondary to warpage.

2. A martempered spring and one given the conventional quench and draw have the same stress range (within the accuracy of the testing machine).

3. A martempered spring goes out of shape less in heat treatment than one

*The second portion of the 1951 William Park Woodside lecture before the Detroit Chapter, ⊕, entitled "Metallurgy in the Mechanical Spring Industry". The first section discussing the metals used for mechanical springs was printed in the May issue of *Metal Progress*. A final section will describe the cause of some failures of springs in service.

†Stress range is the difference between the calculated minimum and maximum working stresses in psi.

Heat Treatment for Stress Relief

quenched and drawn. (Warpage can of course be further controlled in any of these processes with quenching or setting fixtures, but these often are slow and expensive.)

4. The reduction of area (or ductility) for an austempered spring steel of equal hardness or a martempered piece is greater than when the steel is quenched to room temperature and drawn to desired hardness.

Stress Relief — When oil tempered or cold drawn spring steel wire or strip can be used to form the desired part, it becomes advisable to remove as many of the residual stresses from the forming operation (if they are not beneficial) as possible. Use the maximum temperature that will not reduce the properties of the material beyond specified values. For most steels this temperature is 750 to 800° F. For some music wire springs 375 to 475° F. is employed, but never when the spring will be exposed to temperatures higher than 212° F. or where maximum endurance is desired. Such low stress-relieving temperatures will, however, give somewhat greater resistance to static load conditions at room temperature.

Theoretically, heating a torsion spring will remove compressive stresses that actually will increase the spring's life, but in practice it is found that the springs creep in shipment or handling because of these trapped stresses, and often they are heated to stabilize the dimensions. Furthermore, all springs made from any hard drawn material need to be heated to develop a more positive elastic limit; otherwise they tend to set at loads well under those they should easily carry. This is illustrated in Fig. 4.

Combined Heat and Stress have another metallurgical effect that must be considered.

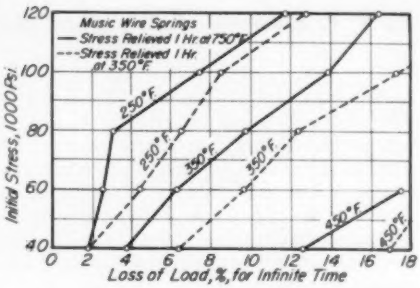


Fig. 4 — Stress Relief at Low Temperature Causes Music Wire Springs to "Set" More Readily When Carrying Loads at Moderate Temperatures (250, 350 and 450° F. Respectively)

Heat-set curves for springs held under static load long enough to establish a true equilibrium of stress versus temperature are shown for various steels in Fig. 5. Each material has definite limits where equilibrium is lost and the set becomes simply a time-temperature factor with little stress being needed. The curves given are of the commoner materials, and an arbitrary limit of 15% maximum set was taken as a commercial limit. Needless to say, all these springs were warmed after coiling (or in some instances are heat treated parts) to remove trapped stresses, so that the values given are the optimum. In these tests the time at heat was 72 hr., which allows equilibrium in steel springs to be obtained, but this is not true for stainless steel. Data for the nickel alloys given in Fig. 6 are plotted in a different way, and give stress versus temperature for definite dimensional changes in seven days.

Fig. 5 — Load Loss at Various Stresses in Steel Springs Tested 72 Hr. at 250, 350, 450 and 550° F.

Setting of Spring Steels

Figures 5 and 6 are for materials which have received no shot-peening and no setting except to press solid once before testing. No data are presented for copper alloys, because none will carry 40,000-psi. stress without beginning to creep and set at 225° F. This even applies to beryllium copper, which, while the best of the good electrical conductors in resisting heat and consequent creep, is still far below steels or the nickel alloys in resistance to set.

Shot-peened springs, due to trapped surface stresses, lose some stability under temperature. Thus, if springs even are cleaned by grit or sand-blasting, the maximum resistance to set will not be obtained until sufficiently reheated to remove the stress and the cold working effects (750 to 800° F. for best results).

Many parts like valve springs need the extra endurance derived from shot-peening. The problem, then, is to adjust the values so that the necessary life is obtained and the setting is under control. Heating to 450 to 500° F. after peening has been found satisfactory in this regard. Other problems must be met by a similar approach to obtain the best all-around results.

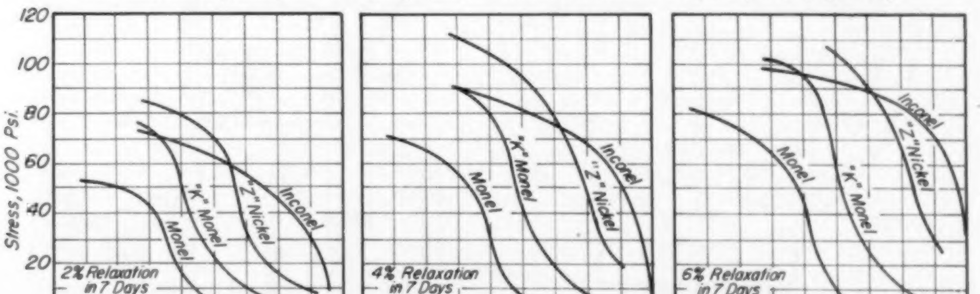
Control of Set — There are ways to help a set condition occurring in highly loaded springs that have been properly stress-relieved. In compression springs the first and most logical would be to coil the spring much too long, stress-relieve it, and press it solid. By experience or testing, the correct coiling length can be determined, and when pressed solid a few times, the springs will come to a length that will give the desired load. If shot-peened, the spring should be heated to 450 to 500° F. before pressing solid. It can be shown that this process traps stresses in the spring which act against those put on the spring in service, so that actually the spring must be compressed a bit before it is stressed at all in the direction of the applied load.

On some extremely high-stressed springs subject to some heat and shock, the above is not enough. The last resort is called "hot setting" — as follows: The heated, shot-peened spring is placed on an arbor and held solid at as high a temperature as will permit the spring to return to the necessary free position (usually between 275 and 475° F.). Hot setting will give better stabilized springs than the first method.

The notation to use shot-peened springs has nothing to do with set. If springs "set" they are overloaded, and will be used up to the elastic limit. With such loading an unpeened spring would not have the necessary life for many uses. As an example, a spring is in use and has a life of 10,000 loadings at a torsional stress of 180,000 psi. with a set of 10% only. The spring was coiled from oil tempered stock, S.A.E. 9254, C-52 hard, and was 20% longer than the desired free length before hot setting. Longer usage continued the set (or the spring would break from this terrific overloading).

Heat Setting — In contradistinction to the method of "hot setting" just described another part of spring metallurgy is usually called "heat setting". Setting, as is possibly

Fig. 6 — Stresses Required to Produce Various Amounts of Relaxation in Springs Made of Nickel Alloys (Betty, MacQueen, and Rolle, A.S.M.E. *Transactions*, July 1942, p. 465)



Setting Procedure for Clutch Disks

well known, is one of the most important heat treating methods used in the fabrication of springs, and is designed to maintain correct dimensions despite shape changes tending to occur in quenching. In the setting process spring steels of high hardness are put into a die (or held by some other fixture to the desired shape) while under heat and pressure.

The setting of spring steels is nearly as old as the industry itself. Patents issued during the Civil War give enough details to operate on today. In general, it can be stated that parts will be held closer to dimensions the harder they are (as put in the setting irons) and the higher the temperature and pressure. Nonferrous alloys can also be set to shape by the use of heat. Since some are precipitation hardening alloys and others are hardened by cold work, they are usually brought to their specified hardness before setting, and in this respect they are not like steel.

By careful control of the heating medium, steel parts can be drawn and set to shape at the same time. Usually a 4 to 5-point spread is held on the Rockwell C-scale hardness. If closer tolerances are needed, the part must be set to shape at a lower temperature than that which will result in the correct hardness. Then it would be tempered to the correct hardness.

The process has not been used much outside the spring industry. It is worthy of attention, and two large plants not usually considered springmakers have found it quite valuable. The first to be described is the Long Mfg. Division of Borg-Warner Corp.

This application pertains to clutches wherein the disk or clutch-driven member is made of high-carbon steel. These parts warp in heat treatment because they are rather thin, running from 0.040 to 0.093 in. thick as the disk increases from 7 to 19 in. Some of these are set flat between parallel plates, and others are set in a die to the desired taper at edges. A typical disk is shown in Fig. 7; it is 9⅜ in. diameter of 0.040/0.043 steel (S.A.E. 1065) to be quenched and drawn to C-41 to 46. The over-all thickness along Section A-A is on the order of 0.100 in., and the central region (diameter B) is dished the same amount.

Drawing Arbors — The setting fixture for such disks as these is shown in perspective in Fig. 8 and as an exploded view in Fig. 9. Here we have two concentric dies, the "top form" and the "bottom form", each heated by gas-fired units. In the exploded unit the top form shapes the section to be dished and the bottom form holds the rest

Fig. 7 — Clutch Disk, 9⅜ In. Diameter, 0.040 In. Thick, Which Is Dished About 0.100 In. in Complicated Pattern

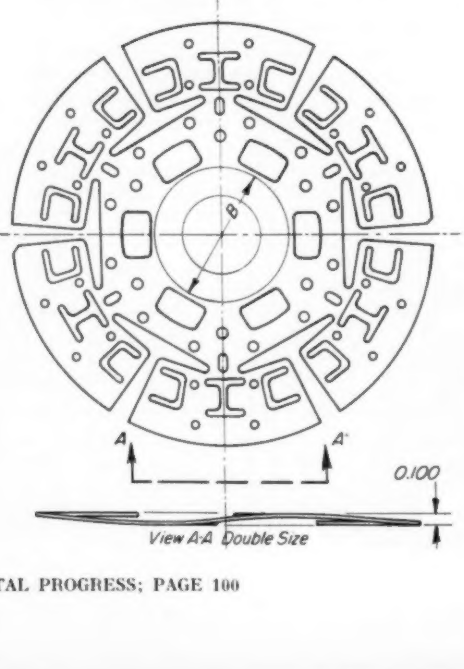
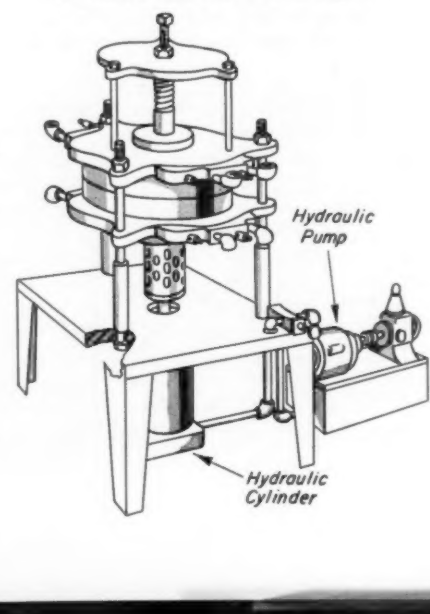


Fig. 8 — Assembly of Drawing Arbor for Clutch Disks Similar to Fig. 7



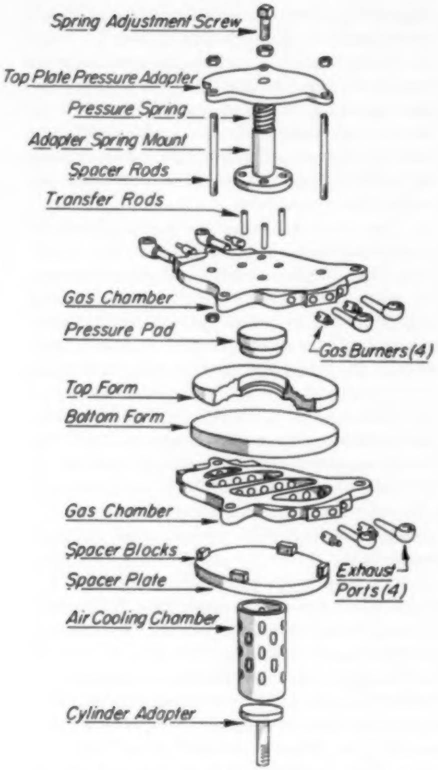


Fig. 9 — Exploded View of Fig. 8

of the disk. The use of two dies rather than a single die allows the better setting of sections of varying thickness. The center portion of this die is held down by spring loading, but sometimes is held down hydraulically with a somewhat smaller cylinder than on the outer die, to the end that about the same unit pressure on the disk surface is obtained.

Operations in the heat treating department are *(a)* harden in an atmosphere furnace to about C-60, *(b)* heat to 350 to 400° F., *(c)* transfer immediately to setting die at 950° F. and close with 750 psi. pressure on the 5 or 6-in. hydraulic cylinder, thus exerting around 10 tons. (The pressure spring in Fig. 9 exerts 1000 lb. on the center portion of the disk.) Holding time is 1½ to 2 min. The resulting Rockwell is C-38 to 43, which is quite satisfactory for this type of disk.

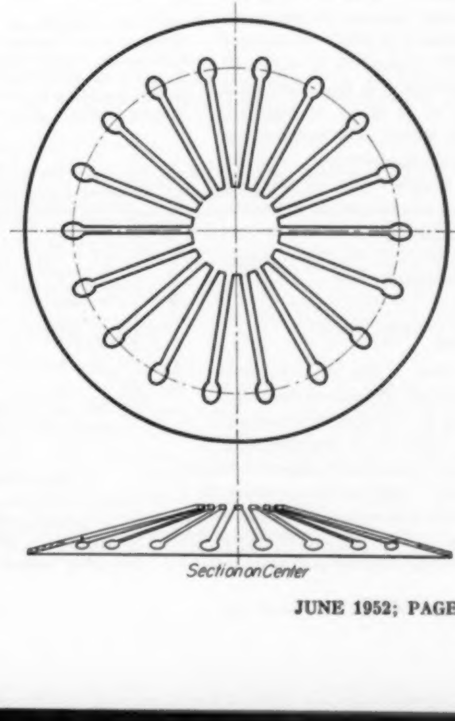
Several flat disks can be placed in a setting fixture at once and heated through. Thus, five parts of 0.060-in. stock can be handled in 5 min. and completely flattened. Longer drawing either in or out of the die can be done when desired, but is not usually necessary. Parts that have been martempered are treated in the same way.

This setting process yields clutch disks of desired shape and fatigue life.

A large automotive manufacturer produces the Belleville spring shown in Fig. 10 for use in place of the usual pressure plate springs in the clutch. Tolerances are close. For example, the part must be less than 0.030 in. out of round after hardening. The inner edge of the fingers after dishing must be in line with the element of the core within $\frac{1}{16}$ in. A definite load-deflection curve must be met on the downstroke after stroking six times ⅞ in. past flat. Notes on manufacturing operations follow:

After blanking, piercing, grinding and coining operations are complete, the parts are heated to 1500° F. for about 45 min. in an atmosphere-controlled furnace, and quenched to C-60 in oil at 140° F. The flat disks are washed and drawn 1¾ hr. at

Fig. 10 — Belleville Spring, 9 In. Diameter, 0.100 In. Thick, Used as Pressure Plate in Automotive Clutch. (J. Geschelin; courtesy *Automotive Industries*)



Shot-Peening for Fatigue Life

735° F. to a hardness of C-47 to 49. When cool, the springs are ready for setting.

The heat setting press contains five dies, each pyrometer-controlled and electrically heated to 900 to 940° F. Two flat disks are put in each of these dies and held for 5½ min. under 250 tons hydraulic pressure. This forms the desired cone angle (consequently with proper load-deflection curve); Rockwell hardness drops to C-40 to 45.

The springs are now shot-blasted equally on both sides, pressed through center six times to remove any tendency for creep and consequent load loss. Should springs be high or low in the load-deflection inspection, another shot-blast on one side can correct the trouble by changing the spring height.

All springs are tested for hardness; those below limits are scrapped, while harder ones are retempered and then reprocessed, after which all inspection operations are repeated.

In these two illustrations of setting one can see the application of the principles first mentioned that control the process. The manufacturer of the disk shown in Fig. 7 sets pieces of high Rockwell hardness at a medium pressure. On the other hand, the producer of the Belleville spring (Fig. 10, p. 101) employs a procedure that sets pieces of medium hardness under a terrific pressure. Both of them obtain the desired commercial product. Either company could change to a different procedure if it became necessary or it were economical. They would still control the operation, however, inside the simple rule of varying the temperature, pressure and the hardness when setting the part to obtain a satisfactory product.

SHOT-PEENING

One of the most important of all the recent developments is called shot-peening. This consists in propelling a stream of particles, usually metallic shot, against the surface of a part, to improve its fatigue properties. The effect is generally attributed to the introduction of compressive stresses in the surface layer and to the slight work hardening action.

Most, if not all, fatigue failures occur at regions stressed in tension, so the compressive stress in the shot-peened object is in effect a preloading device, and cancels out some of the stress applied in service. The net effect is that actual service stresses are reduced to a safe level.

The increase in fatigue life is a definite proportion of the fatigue range of the material. Thus, in completed Goodman diagrams for wire sections 0.207 in. or less showing minimum life in coiled springs we find representative stress ranges for various materials as shown in the tabulation at the bottom of this column.

This effect is further shown in the accompanying Goodman diagram (Fig. 11) for all materials of valve spring quality in 0.207-in. sizes and less. This diagram applies to stress ranges for carbon steel, alloy spring steel and cold worked wire such as music wire.

On larger spring sections similar increases in values hold with sound material. It must be realized that even an increase as small as 10% in the fatigue range could take a spring which was just on the borderline and make it very successful. The percentage life increase, which is often reported, is virtually astronomical, but the figure is very misleading as to what basically happened to the material.

This process, which adds more life to springs than any alloy steel or heat treatment has been able to do, is therefore of greatest importance to the spring industry. There should be some test to determine the degree and completeness of peening, but today there is absolutely no way to do this but fatigue-test the spring (or control samples of springs run at the same time).

The "Almen strip" can be used for comparative fig-

Fig. 11 — Goodman Diagram for Wire of Valve Spring Quality (Either Carbon or Alloy Steel, in the Heat Treated or Cold Drawn Condition) With Line Showing Increase in Stress Range Derived From Shot-Peening

Material	Corresponding Range Unpeened	Peened	Increase
Carbon spring steel (S.A.E. 1074)	75,000 psi.	115,000 psi.	54%
Alloy spring steel (S.A.E. 6150)	70,000	115,000	60
Stainless Type 302	45,000	90,000	100
Phosphor bronze (S.A.E. 81)	15,000	30,000	100

ures as long as the kind of shot, size of shot and feed of shot are constant. The strip is of standard rectangular size, hardness, and type of steel, held to a heavy backing plate by bolts in each corner. As the shot impinges on the top surface, that surface increases slightly in area; when removed, the flat steel now assumes an arc shape. By keeping this arc the same height at all times for a given time of exposure, the machine can be said to be in a stable condition. Some metallurgists (and some engineers) have put an arc height on a print with the vain hope it would control the quality and the fatigue characteristics of the part. Nothing could be further from the truth. After fatigue tests have been run in a given plant under known operating conditions, the Almen strip is certainly a splendid machine check and an aid to uniformity — but nothing more.

In order to investigate this problem, the Barnes-Gibson-Raymond laboratory made some standard springs for our fatigue testing machine.* For this test we obtained six lots of shot of various kinds as listed in Table III. Their hardness was checked independently by Chrysler Engineering Laboratories and Battelle Memorial Institute.

The standard springs for test were carefully peened alongside Almen A-2 strips in the Wheelabrator, and A-2 strips were also run through the machine itself. All Almen strips were checked for uniform hardness before using. An average of the curvature of the peened Almen strips for the different times in the Wheelabrator for each lot of shot is also given in Table III.

It will be noticed that the arc height quickly reaches a fairly high value for the shot in question and then continues to rise very slowly with extended time in the Wheelabrator. There is one exception — the 15-min. run of P-16, Lot 100 shot, but the strips for the 5-min. run were C-45.5, and C-48 for the 15-min. run. Since the lower the Rockwell hardness, the higher is the Almen reading, this may partially explain this discrepancy. (Often the variation in Rockwell hardness of the test strips causes a reading in excess of the desired limits. This source of error must be watched at all times and proper allowances made.)

These tests also show conclusively that the Almen reading goes up as the shot size increases. They also show that for the same size shot the Almen reading goes up somewhat as the shot hardness increases. (Compare the last three columns.) In this respect the difference appears to be somewhat more pronounced for the shorter peening times, although it holds true in every instance in this series of tests.

The difference in the Almen readings taken before starting the shot-peening of springs and after the finish of the peening tests — that is, the difference between the first and last lines of the table — must be attributed to breakdown of the shot. For hard shot there is a great difference; for the two softer lots of shot there is none (within experimental error).

After shot-peening, all the springs in this test were heated to 450° F. for 30 min. Then they were placed in the fatigue machine in sets of eight at the stress ranges which would determine the maximum for enduring ten million loadings. Such endurance limits given in Table IV have been

*This machine and testing method as well as the standard springs were described in "Shot Blasting and Its Effect on Fatigue Life" presented by the present author before the 1950 symposium on "Surface Treatment of Metals" and published in a book of that name by American Society for Metals.

Table III — Intensity of Peening Effect as It Relates to Size and Hardness of Shot and to Time

Item and Time	P-46	P-28	P-16			
			Lot 100*	Lot 101	Lot 102	Lot 103
Shot diameter, in.	0.046	0.028	0.016	0.016	0.016	0.016
Hardness by Chrysler	65	63	35.5	65	48	27.6
by Battelle	65.1	63.4	33.7	59	46.8	25.1
	Curvature of Almen Strip					
2 min., no load†	0.0385	0.0215	0.0077	0.009	0.010	0.008
5 min., with springs	0.0281	0.020	0.008	0.0092	0.0075	0.0042
15 min., with springs	0.038	0.0235	0.0075	0.0117	0.009	0.007
30 min., with springs	0.039	0.0242	0.0092	0.0127	0.0115	0.0085
120 min., with springs	0.0465	0.0267	0.012	0.0155	0.0147	0.013
2 min., no load‡	0.015	0.0125	0.008	0.005	0.0102	0.0067

*This is a 0.40% carbon steel; the others are cast iron.
†Preliminary run with new shot; Wheelabrator belt stationary.
‡Final run after shot had been used 4 hr. Wheelabrator belt stationary.

corrected to allow for the set which occurs during the test.

The first thing to notice in Table IV is that shot-peening increases the endurance limit of the springs. The lowest figures in the table mean that the safe stress range of nonpeened springs has been increased 19.3%. For the highest endurance limit the increase in safe stress range is 56.7%.

It is at once apparent that the P-46 shot is too coarse for these springs. While it has improved the endurance limit, almost all the values in the table are lower than for any of the other shot. There would appear to be a tendency to overpeen with this shot for long times, but the differences are hardly more than the experimental error.

When P-28 shot are used for 15 min., the minimum stress appears low. Actually, for some unknown reason, this was caused by the springs setting more than usual during the tests. The stress *range* is comparable to those after peening with this shot for other times except for 2 hr. The low figure does not necessarily indicate much, because we have the possibility of a ±3000-psi. machine and setup error. However, it might well be said that the springs are shot-peened to the practical limit.

Data for the various lots of P-16 shot show that we are obtaining endurance limits with it which are strictly comparable to P-28 shot. Furthermore, there is practically no difference (as far as the endurance limits obtained are concerned) whether the shot is hard or soft within the limits of the hardnesses used.

There is absolutely no correlation between arc heights of Almen strips given in Table III and the corresponding endurance limits in Table IV. For example, we found almost exactly the same endurance limit for springs shot-peened 15 min. with P-16, Lot 103 shot and with P-28 shot for 30 min. The arc heights were respectively 0.007 and 0.0242 in. It would therefore seem that arc height of itself does not mean much unless the shot used is specified as to size and hardness. Even then it would still appear to be desirable to set up a minimum arc height by running fatigue tests and attempting to sesure some kind of correlation between arc height, the coverage, and endurance limit for that particular shot. All of this leads to the following conclusions:

1. Throughout the range of hardness tested in the shot there was no significant effect on the endurance limit of the springs after peening.

2. The size of shot, within limits, did not affect the endurance. For instance, P-16 or P-28 shot gave comparable results on these springs (made of 0.148-in. wire), but the results for P-46 shot were generally lower than for P-16.

3. These springs can be overpeened with the coarse P-46 shot. This was impossible under the same conditions with P-16.

4. There is no relationship between Almen strip arc height and the endurance limit.

5. After obtaining reasonably good coverage there is little advantage to be gained by continued peening.

6. The smooth, nonpeened appearance of samples after peening with steel or soft shot will cause a departure from the usual visual inspection methods.

7. The use of soft materials giving the maximum fatigue life (P-16, Lot 100) results in true economy of operation. Use of cut wire or heat treated cast steel shot for peening instead of cast iron is good practice.

8. Grit is designed to cut and clean; it should never be used to peen. It contains large particles that may spoil the springs, and sharp ones that produce stress raisers.

Heating After Peening — Shot-peening,

Table IV — Highest Stress Range for 10,000,000 Loadings After Shot-Peening Various Times

Stress range for springs before peening: 20,000 to 95,000 psi.

Shot	5 Min.	15 Min.	30 Min.	120 Min.
P-46	13,000 to 114,000	<20,000* to 115,000	16,750 to 106,200	11,700 to 110,500
P-28	14,200 to 123,600	13,300 to 110,000	12,600 to 120,000	10,930 to 113,750
P-16 Lot 100	13,500 to 116,000	10,750 to 118,200	16,000 to 115,000	>12,750* to 120,500
P-16 Lot 101	11,500 to 122,500	10,000 to 117,500	10,000 to 117,500	11,100 to 120,250
P-16 Lot 102	12,300 to 123,750	10,750 to 125,800	13,000 to 120,500	11,000 to 119,200
P-16 Lot 103	16,000 to 122,500	12,200 to 120,000	10,750 to 118,000	11,000 to 121,000

*Insufficient springs to complete the test and determine minimum figure accurately.

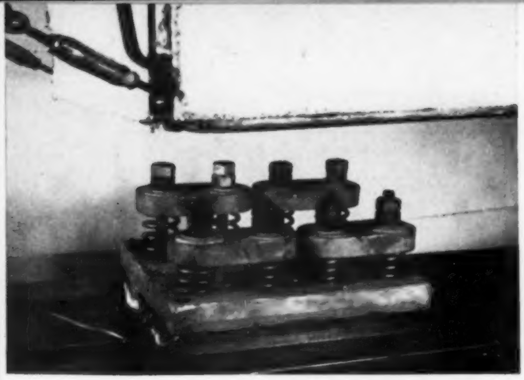


Fig. 13 — Springs on Fatigue Test Stand, With Furnace in Position to Be Lowered

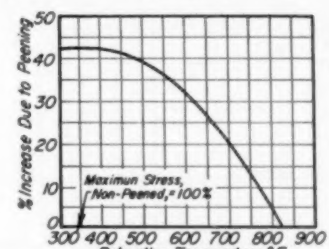
since it is a mechanical working process, can be modified by heat treatment. If springs are heated sufficiently after shot-blasting, the benefits will be removed and the endurance limit will drop to that of the original wire. If the springs are heated still higher, then this original limit, as-received, will be altered. Specific values are shown in Fig. 12.

Continuing our work on the effects of heat on shot-peened and nonpeened springs under operating conditions, tests have been run for fatigue life at various temperatures. We used our standard fatigue machine and built a furnace which could be lowered over the springs under test. (This machine has been described in the 1940 ⊕ paper already noted; Fig. 13 shows the springs in position with the furnace ready to be lowered.)

For high-temperature runs an insulated chamber covers the spring retaining seats, heated electrically with the usual pyrometric controls. The chamber was tested for uniformity of temperature by numerous thermocouples before, during, and after the series of tests.

Standard test springs were produced from several valve spring steels. The S-N endurance curves were run out at the start and thereafter a lower stress of 20,000 psi. was used. Springs were all set to this minimum, and the stroke of the machine changed until the stress range was sufficient to break one of the eight springs in the fixture. These test specimens were run at various temperatures for 96 hr., obtaining 10,000,000 cycles. Springs that did not fail were weighed and the load loss plotted, resulting in data plotted in the left graph in Fig. 14.

Fig. 12 — Effect of Heating Peened Springs Is to Reduce Maximum Stress. In these tests the maximum stress in the nonpeened condition was 95,000 psi. This equals 100% on the vertical scale. Peening increased this stress 42.5% to 135,000 psi.



At room temperature the usual results were obtained, but as the temperature increased there was a new development. If we assume that the operation of the machine could be subject to an error of ±3000 psi., we find the unpeened carbon valve spring steel to change but little up to 250° F., but the peened springs set considerably more.

From 250 to 400° F. unpeened springs became progressively better while the peened springs became progressively worse. After 10,000,000 cycles at 400° F. the 35,000-psi. increase in this steel due to shot-peening has sunk to less than 10,000 psi. There was every indication that had the test been continued to higher temperatures the two curves would have become one. All the figures were calculated back to the correct modulus obtained by testing the load on the springs for the temperature under consideration.

These tests on carbon steel springs were discontinued at 400° F. because a set of more than 15% would have been obtained with continued running, as is proved by static load tests. It must be remembered that the *maximum* stress is not applied, in the running of a spiral spring, for over 1° of the circumference or 1/360 of the time; during the rest of the time much lower stresses are carried and hence the running tests look better than when checked at a constant load. If we now plot the endurance limit on such a static load-loss curve, we have Fig. 15.

This combination of data gives a rather interesting picture of the utility of springs under heat and varying loads — for example, in an automatic transmission where temperatures run up to 300 or 350° F. We see that we could run a stress of 102,000 psi. at 350° F. if a 10% set is allowable. If limited to 5% set, only 60,000 psi. total stress (shear and torsion) could be used. It therefore is apparent that fatigue failure is not the controlling factor in this type of use, but that setting is more important.

To show up this detail, curves for S.A.E. 9254 Cr-Si

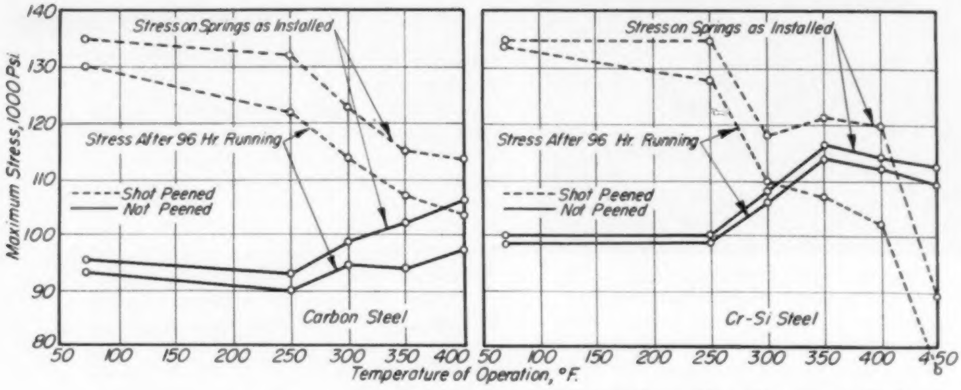
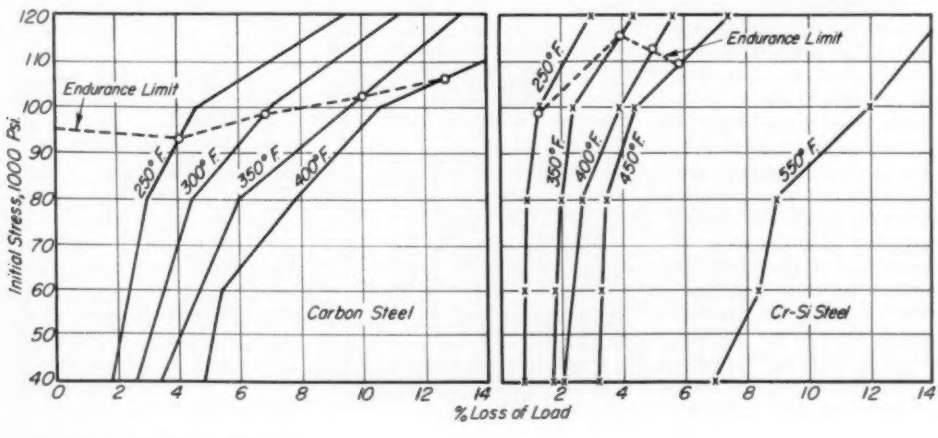


Fig. 14 — Operating Stresses at Various Temperatures for 10,000,000 Loadings. Carbon steel valve springs at left; chromium-silicon steel (S.A.E. 9254) springs at right

valve steel are given at the right of Fig. 14 and 15. The superiority is marked and demonstrates that the real advantage of alloy steels in most mechanical springs is simply heat resistance.

Apropos of shot-peening, it is obvious that if a stress can be put into metal by mechanical force, it can be removed by the same method. Therefore, if parts are stressed beyond the elastic limit in one direction the internal compressive stresses can be removed, or will certainly be reduced, so that the fatigue life under tension stress will be adversely affected. It follows, also, that on springs which work from a zero stress to high values in both directions — as, for example, a compression spring being used in both compression and tension — the high fatigue values expected of a shot-peened product will not materialize. Using the same reasoning, it is sometimes possible to devise methods for slightly increasing the stresses due to shot-peening by other types of cold working. In another sense, springs heat treated after coiling can have compressive stresses set up by the heat treating operations, and these may be further increased by the peening operation. On the small sections we are considering, this is seldom done because of the increased tendency to hardening cracks, but on large springs it is possible. It has become a standard practice in many companies making axle shafts.

Fig. 15 — Initial Stress Versus % Load Loss at Constant Length for "Infinite" Time (10,000,000 Loadings) in Valve Springs Made of Carbon Steel (Left) and of Chromium-Silicon Steel (Right). These springs were not shot-peened



ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

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Why 3 Per Cent Chrome Steel Makes Good Castings for Wear Resistance

Castings of 3 per cent chromium steel have been used in substantial tonnages, for many years, for various equipment parts demanding good wear resistance. Such castings offer an excellent combination of hardness and toughness. Typical applications are crusher parts used in rock- and ore-crushing equipment, swing hammers for pulverizing coal, railroad switch frogs, gears, pulleys, sheaves, and other castings that must meet severe conditions of wear.

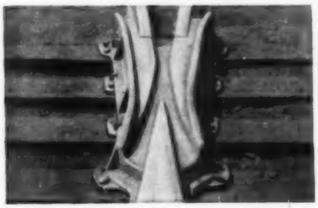


Fig. 1. Railroad switch frogs, which are subject to severe wear, give outstanding service when cast of 3 per cent chromium steel.

The 3 per cent chromium steels, are normally produced in a carbon range of 0.30 to 0.50 per cent. They exhibit excellent depth-hardening properties, which simplify heat-treatment and insure uniformity throughout heavy sections. The analysis is usually modified by a molybdenum addition, since this element aids in increasing hardenability.

Fig. 2. Grating for top of shake-out machine is cast of 3 per cent chromium steel to give good wear resistance and long life.

Properties Improved by Heat-Treatment

The best properties of 3 per cent chromium steels are developed through heat-treatment. Generally, this consists of a normalizing treatment from 1650 deg. F., followed by tempering in a range between 1000 and 1250 deg. F., depending on the physical properties desired. Double normalizing is sometimes used to obtain further improvement in the grain structure. With carbon on the high side of the specification, air-quenched castings show a Brinell hardness number of over 400 in 3-inch sections. This hardness is practically uniform throughout the section. Oil quenching is employed to produce higher hardness and depth of penetration, and even in a 4-inch section, a hardness number of over 500 Brinell is obtained.

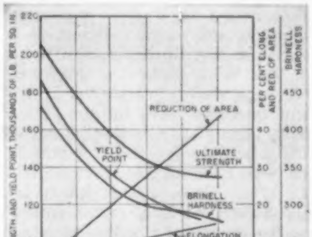


Fig. 3. These curves show the response to tempering of a 0.37 per cent carbon, 2.93 per cent chromium, 0.35 per cent molybdenum steel previously normalized from 1650 deg. F.

The steel also shows good response to tempering. After a normalize and a 1100 deg. F. treatment, it has a tensile strength close to 150,000 pounds per square inch, with an elongation value of about 12 per cent, and a Brinell hardness of about 300. When greater ductility is required, tempering should be done at higher temperatures. However, in such instances, some strength and hardness are sacrificed.

Fig. 4. Photomicrograph of 3 per cent chromium steel normalized from 1650 deg. F. and tempered at 100 deg. F. (X250). The pseudo-martensitic structure is well suited to resist abrasion.

Effect of Other Alloy Additions

Molybdenum in the range from 0.30 to 0.50 per cent will improve depth-hardening characteristics and aid in reducing susceptibility to temper brittleness in the lower temperature ranges. If the molybdenum-bearing steel contains relatively high carbon (0.40 to 0.60 per cent) additions of approximately 0.08 to 0.10 per cent vanadium provide greater uniformity in hardening. Small additions of silicon increase strength and hardness and this element is sometimes increased to 0.80 or 1.00 per cent. Manganese is added in amounts between 0.50 and 0.80 per cent.

Metallurgical Service Available

When you have occasion to produce castings for applications involving severe abrasion and wear, it will pay you to investigate the advantages of using 3 per cent chromium steel. If you need help on some specific metallurgical problem, be sure to consult one of ELECTROMET's specially trained metallurgists and engineers. For further information, write to the nearest ELECTROMET office: in Birmingham, Chicago, Cleveland, Detroit, Los Angeles, New York, Pittsburgh, or San Francisco. In Canada: Welland, Ontario.

Personal Mention

Allen G. Gray

E. C. Wright

John H. Hollomon

Two more steps in the program of editorial expansion for *Metal Progress* are now announced. Dr. Allen G. Gray ⊕ has accepted appointment as consulting editor in the field of metal cleaning, corrosion of metals and corrosion resistant coatings, and will carry on the work so well started by the late Adolph Bregman. Dr. Gray's first contribution appears on p. 77 of this issue. E. C. Wright ⊕ has also been appointed consulting editor in his specialty of steel plant practice. These men, in addition to Harold J. Roast ⊕, who has served as consulting editor in the foundry field for some time, will bring seasoned judgment to bear on the respective branches of the broad field covered by the American Society for Metals.

Dr. Gray holds a master of sciences degree in metallurgy from Vanderbilt University and obtained a doctor's degree in chemistry at the University of Wisconsin in 1940. Since then he has been with E. I. duPont de Nemours & Co. He is a member of the American Chemical Society, has served as chairman of the electrodeposition division of the Electrochemical Society, and is editor-in-chief of the second edition of *Modern Electroplating*, a book sponsored by that Society.

E. C. Wright, known to many friends and former associates in the Pittsburgh region as "Chet", joined National Tube Co. in 1926. He was plant metallurgist and then assistant to the president, remaining with the firm until 1947 when he joined the faculty of the University of Alabama as head of the department of metallurgical engineering. Professor Wright is a graduate of the University of Michigan in chemical engineering and holds a master's degree from the University of Pittsburgh in metallurgical engineering. After three years' service in the Army during World War I, he was with Ford Motor Co. for two years, then joined the University of Alabama faculty as an associate professor in metallurgy from 1921 to 1926. While with the National Tube Co. during World War II, he did extensive work for the Army serving as chairman of the demolition bomb committee, for which he was cited by the government in 1945. He was a recipient of the Robert W. Hunt medal award of the American Institute of Mining and Metallurgical Engineers for a paper on bessemer steel.

Wm. H. Eisenman
Secretary
American Society for Metals

Charles A. Blesch ⊕ resigned his position as manager of the industrial furnace division of Natural Gas Equipment, Inc., Los Angeles, to take a position as sales manager of Heat & Control, Inc., San Francisco, engaged in design, engineering and sale of equipment for many varieties of industrial process heating.

John H. Hollomon ⊕ was recently named manager of the metallurgy research department of the General Electric research laboratory, succeeding William E. Ruder ⊕ who retired January 1. A native of Norfolk, Va., Dr. Hollomon received his B.S. degree from Massachusetts Institute of Technology in 1940 and his D.Sc. degree from the same school in 1946 for work in metallurgy. After serving on the faculty of M.I.T. and of Harvard University, he served in the U. S. Army from 1942 to 1946, where he attained the rank of major. While in the Army, he was chief of physical metallurgy at the Watertown Arsenal, Watertown, Mass. In 1946, Dr. Hollomon joined the General Electric research laboratory and was later made assistant manager of the metallurgy research department. He has authored and co-authored some 40 papers in physics and metallurgy journals, as well as a book, "Ferrous Metallurgical Design". His professional awards include the Rossiter W. Raymond award of the American Institute of Mechanical Engineers in 1946, and the Alfred Noble award of the Combined Engineering Societies, 1947, for a paper entitled "The Mechanical Equation of State".

Clyde Llewelyn ⊕, vice-president of Bliss & Laughlin, Inc., Harvey, Ill., has accepted a six months' government assignment in Washington, D. C., to act as chief, cold finished steel bar section, iron and steel division, National Production Authority. Mr. Llewelyn will perform this service on a loan basis and will return to his position with Bliss & Laughlin.

Personals

Robert C. Gibbons ⊕, past chairman of the New Jersey Chapter, has been transferred from Eclipse Pioneer Div. of Bendix Aviation Corp., Teterboro, N. J., to the Utica (N. Y.) Div. of Bendix where he will take over the position of chief metallurgist.

D. E. Hamby ⊕ recently resigned as senior metallurgist at Oak Ridge National Laboratory to accept a position as research engineer at Union Carbide & Carbon Research Laboratories, Inc., Niagara Falls, N. Y.

I. A. Oehler ⊕, director of metallurgy and research for American Welding & Mfg. Co., Warren, Ohio, was named to the new post of administrative assistant to the executive vice-president. He will continue to direct the company's research activities.

Emilio Jimeno ⊕ was elected a full member of the Spanish Real Academia de Ciencias Exactas, Fisicas & Naturales. As part of the initiating ceremony, Dr. Jimeno addressed the Academy in Madrid on April 2 on the subject "Science and Society".

John E. Newlin, Jr., ⊕ has been appointed sales manager of the steel division of Henry Disston & Sons, Inc., Philadelphia. He succeeded **H. D. Siegfried** ⊕ who retired after 27 years with the company.

Four ⊕ members at the Carpenter Steel Co., Reading, Pa., have been promoted from assistant branch managers to branch managers with territories as follows: **W. J. Ervin** ⊕, Indianapolis; **W. C. Kunkelman** ⊕, Cincinnati; **H. M. Rittger** ⊕, St. Louis; and **R. P. Uhl** ⊕, Dayton, Ohio.

W. E. Gustafson ⊕ was recently appointed to the position of design engineer at Solar Aircraft Co.'s Des Moines plant.

Charles L. Moseley ⊕, for the past 13 years manager of the Rochester, N. Y., office of Chase Brass & Copper Co., has been transferred to Waterbury, Conn., where he will assume the position of district manager of the Chase Waterbury territory, including supervision of its branch warehouse.

Personals

S. L. Channon ⊕ recently became associated with Kaiser Aluminum and Chemical Corp., Spokane, Wash., as research metallurgist. He was formerly with E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Bernard P. Planner ⊕, a senior process and metallurgical engineer with Douglas Aircraft Corp., Los Angeles, is also teaching a course in "Powder Metallurgy" at the University of California. This subject is being taught for the first time on the West Coast.

John W. Schaetzler ⊕, who recently graduated from Purdue University, is employed by United Aircraft Corp., East Hartford, Conn., as mechanical research engineer.

Donald A. Douglas, Jr., ⊕, formerly with Hughes Tool Co., Houston, Tex., is now with the metallurgical division of Oak Ridge National Laboratory.

Paul W. Kloeris, Jr., ⊕ has been recalled to active duty with the 44th Division of the Illinois National Guard and is stationed at Camp Cooke, Calif.

Emo D. Porro ⊕ was recently appointed manager, chemical and metallurgical engineering section of the Stanford Research Institute, Stanford, Calif. This section does applied research for western industries in chemical engineering, process metallurgy, physical metallurgy and ceramics.

Herbert D. Wedge ⊕, recently graduated from Purdue University, is now employed in the Electro-Metallurgical Division of Union Carbide & Carbon Corp., Marietta, Ohio, as a junior metallurgical engineer on a production training program.

Bertram J. Toolin ⊕ has been recalled to active duty in the U. S. Air Force and is now stationed at San Antonio, Tex.

Herman Rischall ⊕, formerly foundry metallurgist for American Hoist & Derrick Co., St. Paul, Minn., has accepted a position as metallurgist for the U. S. Navy at the Naval Proving Ground, Dahlgren, Va.

Personals

James Bliss Austin, director of research, United States Steel Co., was chosen to present the Edward Orton, Jr., Fellow Lecture at the 54th annual meeting of The American Ceramic Society in Pittsburgh, held from April 27 to May 1. The lecture, a yearly feature of the meeting, was on "The Thermal Expansion of Non-Metallic Crystals". Dr. Austin, author of more than 45 technical papers, has been with U. S. Steel in the research laboratories since 1928. A series of promotions since that time culminated in his appointment as director of research in 1946. Dr. Austin, who gave the 20th Orton Lecture, graduated from Lehigh University in 1925 with a chemical engineer degree. In 1928 he received his Ph.D. degree in chemistry from Yale University. He is also a member of the American Chemical Society, the American Institute of Mining and Metallurgical Engineers, the American Iron and Steel Institute, and the Optical Society of America.

H. B. Osborn, Jr., technical director of The Ohio Crankshaft Co., Cleveland, who also handles that company's advertising, was picked recently by the t.f. Club of Cleveland area as "1951 Advertising Manager of the Year". The t.f. club is made up of publishers and space salesmen and annually selects the advertising manager who, in the opinion of the judges, achieves the greatest success in accomplishing the objectives he has set up for his company's advertising program.

Les Morrell, employed by Revere Copper & Brass, Inc., St. Louis, was elected chairman of the St. Louis Section of the American Society of Mechanical Engineers. He is a former secretary of the St. Louis Chapter.

C. F. Nagel, Jr., chief metallurgist of Aluminum Co. of America, has been elected vice-president of the company. He is also chairman of the company's technical committee and of the research policy committee.

Clayton O. Matthews, formerly research metallurgist with Kaiser Aluminum and Chemical Corp., Spokane, Wash., now is with the University of California Scientific Laboratory, Los Alamos, N. M., in a similar capacity.

Personals

E. S. Rowland has been promoted to chief metallurgical engineer of The Timken Roller Bearing Co., Canton, Ohio. He was formerly research metallurgical engineer, a position now filled by the promotion of **D. J. Girardi**. Dr. Rowland has held various positions in the metallurgical department at Timken which he joined in 1935 after receiving his doctor's degree from the University of Michigan. He is a member of the American Institute of Mining and Metallurgical Engineers, the Society of Automotive Engineers, the Iron and Steel Institute of Great Britain, and the American Physical Society. Dr. Girardi joined Timken in 1946 and is a member of the American Institute of Mining and Metallurgical Engineers.

Charles M. Cooley, formerly assistant chief mining engineer at Climax Molybdenum Co., Climax, Colo., is now associate editor of *Mining Engineering*, located in New York.

A. J. Harmody has accepted a position with the Standard Steel Spring Co., Armor Plate Div., Detroit, as senior metallurgist. He was previously with the Shuron Optical Co., Rochester, N. Y., as chief metallurgist.

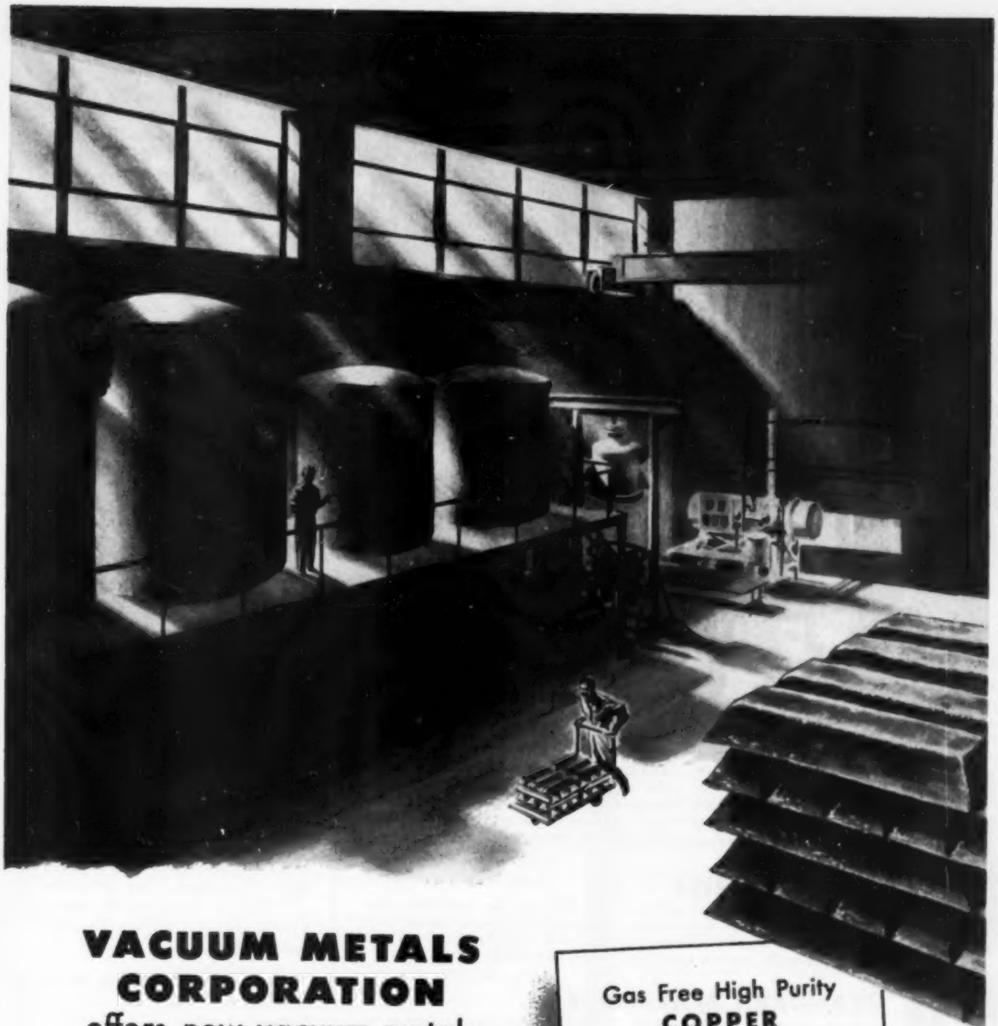
Marvin L. Buehler has changed positions from metallurgist at the Bureau of Mines, Boulder City, Nev., to research metallurgist with the California Research & Development Co., Livermore, Calif.

George J. Thompson has accepted a metallurgical position with Universal-Cyclops Steel Corp., Titusville, Pa.

M. M. Murphy has accepted a position as industrial engineer with Department of Army, Office, Chief of Ordnance, Field Inspection, Birmingham (Ala.) Ordnance District.

Richard D. Schoch is now associated with Phillips Petroleum Co., Bartlesville, Okla., as a metallurgical engineer.

Leonard F. Sansone, Jr., is now employed by the National Tube Division of U. S. Steel in Pittsburgh as a planning and development engineer.



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Personals

Howard F. Taylor, a faculty member in the department of metallurgy, Massachusetts Institute of Technology, has been promoted to the rank of full professor.

Gustaf Peterson, a member of the Philadelphia Chapter for 31 years, is consulting metallurgist for Edgcomb Steel Co., Philadelphia.

Paul A. Lockwood, who recently graduated from Ohio State University, is now employed as a production metallurgist at Thompson Products, Inc., Cleveland.

Carl Wessel is now consulting engineer to the Western Gravity Casting Co., Los Angeles.

Lawrence G. Glasgow is presently an associate engineer in the materials and standards section of Westinghouse Air Arm, Friendship Airport, Baltimore, Md.

C. H. Fellows has been promoted from head of the chemical division, research department of the Detroit Edison Co., to director of the engineering laboratory and research department.

Frank LaBelle is now employed by Climax Molybdenum Co. in their research department, Golden, Colo., as a chemist.

Leonard J. Synk, who recently graduated from Fenn College, Cleveland, has accepted a position as metallurgist with the Parker-Street Castings Co., in the same city.

Francis L. Shubert, formerly of Battelle Memorial Institute, Columbus, Ohio, is now employed by the Libbey-Owens-Ford Glass Co., Rossford, Ohio.

Everett B. Cooke was recently elected vice-president and treasurer of Process Heating, Inc., Brooklyn.

William H. Myers, formerly research engineer with Bethlehem Steel Co., is now product and process development engineer, Wire Rope Division, Jones & Laughlin Steel Corp., Muncy, Pa.

Jack Schwartz, formerly at the Frankford Arsenal, is now plant manager and metallurgist at the Redco Tool Co., Shot (A.P.) Division, Red Lion, Pa.

Fast Cutting

(Continued from p. 96)

Detailed tool-life curves for the various steels cut with 78 (a finishing grade of carbide), 78B (a general-purpose grade of carbide) and 18-4-1 (run with 20:1 soluble oil) are given in the two publications, and from these the metal engineer may select proper cutting speeds, predict production rates, and estimate machine tool requirements.

Microstructural correlations pertaining to machinability have now been shown in *(a)* gray cast irons; *(b)* ductile irons with spheroidized graphite; *(c)* a few high-temperature alloys such as Inconel "X", 16-25-6, and S-816; and *(d)* carbon and alloy steels, wrought and cast.

In both gray and ductile irons enormous improvement in tool life can be achieved by decreasing the combined carbon which is present as pearlite in the matrix or major constituent. In common gray irons it is easy for a slight change in tramp alloy in the cupola to convert a readily machinable iron into one which chews up the tools. Differences in relative tool life may be as much as 20 to 1. The microstructure may appear very similar, but a sharp eye can readily recognize some cementite masquerading as ferrite — and the two are ordinarily differentiated by characteristic outlines or contours of the grains (Fig. 3, p. 96).

Work is now being done on titanium alloys by Metcut Research Associates, but it is still too early to present microstructural correlations. However, it appears that increased carbon resulting in the formation of complex carbides decreases tool life.

On all materials "skins" are detrimental to tool life. In titanium alloys this factor is accentuated to the n^{th} degree.

FLAME WASHING

In some general remarks about removing metal with commercial oxygen processes, E. M. Holub, service engineer for Linde Air Products Co., New York City, said that flame washing, or flame finishing, has intrigued engineers for years but prior to the discovery that iron powder stabilizes the oxidizing reaction, the process was used only to a limited extent. Without powder, it is difficult to maintain dimensions within practical limits. Powder washing or flame finishing is not competitive with

(Continued on p. 122)

ALLOY TYPE 17-4PH*

Norman S. Mott
Chief Chemist and Metallurgist

Alloy type 17-4PH is a precipitation hardenable alloy designed for use where a reasonably low cost material having high hardness, strength, elasticity, and corrosion resistance is desired. Its corrosion resistance exceeds that of 12-14% chrome alloy usually used to secure similar mechanical properties, and approaches that of 18 and 8. It is especially resistant to sea water corrosion and pitting; and is recommended for use in ship propellers, pump impellers and other marine applications of a wide variety. In food and chemical industries its use in any mildly corrosive application satisfactorily handled by 18% chrome alloy is recommended, where wear, galling or erosion is a problem.

It is readily machinable in the solution annealed condition and, when hardened, has in addition to the excellent mechanical properties of strength and elasticity, an appreciable amount of ductility and toughness.

The typical chemical composition is: C 0.05; Cr 16.5; Ni 4.0; and Cu 4.0%. Mechanical property values in castings are:

	As Solution Annealed	*As Precipitation Hardened*
Tensile Strength psi.	152,000	179,000
Yield Point psi.	83,000	150,000
Elongation %	5%	4%
Reduction of Area %	8%	7%
Hardness—Rockwell "C"	34	41
Impact Resistance—Izod	27	17

Heat treatment consists of solution annealing the alloy by water or oil quenching, or by air cooling from 1800–1850°F after one-half hour at temperature, followed by precipitation hardening for one hour at 850–900°F with air cooling.

The hardening treatment produces at the most only a light heat tinting discoloration which is easily removed by a short light pickle in warm dilute nitric acid. Of special importance is the fact that stress relieving is unnecessary since no cracking of any sort is ever produced, as is sometimes the case in the hardenable chrome alloys.

Welding is accomplished by any of the usual methods using 17-4PH welding rod and no intergranular corrosion embrittlement results from the welding heat effect. If fully hardened material is welded, a hardening treatment at 900°F will bring the properties of the weld joint close to those of the parent metal.

Close consideration of this alloy shows that it fills a much needed gap in the range from high mechanical properties to good corrosion resistance in the low cost alloy field.

*Developed by Armco Steel Corporation

Copies of this article reprinted on heavy stock for convenient filing are available on request.

Fast Cutting

(Continued from p. 120)
machine tools where the work can be properly set up; however, it is competitive to portable hand tools, due to the high rate with which it takes off metal. Thus, it can economically replace slower chipping and grinding processes without sacrificing surface quality. The process has especially appealed to foundrymen.

A special nozzle of high preheat capacity and low oxygen velocity not only controls the forward gouging motion but simultaneously supports a stable lateral motion on stainless steels and on carbon steels, clean or dirty. The operator has a constant view of the reaction zone, and can detect and remove all defective material and sand inclusions which show up as spots of different light intensity in the reaction zone. The washing oxygen stream can be easily directed against them until they are removed. It is fast, quiet and less fatiguing to the operator than chipping or grinding.

Mr. Holub said that powder washing is eliminating the bottleneck frequently found on the foundry cleaning floor. It rapidly removes riser pads, fins, sand incrustations, cracks or tears, chill nails and chaplets. For example, a heavy mining machine casting formerly required 1 hr. grinding time; it is now being powder washed in 5 min. In addition, it is reclaiming castings with hundreds of pounds of sand penetrations — castings that previously would have been uneconomical to reclaim. It has proven to be an efficient tool for removing repair weld reinforcements and for blending weld metal to the surface of the casting.

Softening Induced by Cold Working*

THIS PAPER has for its objective the determination of the changes which occur in the physical properties of metals, and the relationship between them when plastically deformed in various ways. It is well known that the temperature at which a metal recrystallizes is lowered as the extent of cold working
(Continued on p. 124)

*Abstract of "Softening of Metals During Cold Working", by N. H. Polakowski, *Journal* of the Iron and Steel Institute, Vol. 169, December 1951, p. 337-346.

Softening Induced by Cold Working

(Continued from p. 122)
is increased, provided the forces of deformation are applied in the same direction, and are of the same kind. The work hardening increases the tensile strength, even though the incipient temperature of recrystallization is altered.

However, if the deformation is changed from tensile to compressive, the incipient temperature of recrystallization usually is increased. This is interpreted to mean that the reversal of the forces of deformation has caused a softening of the metal. The changes in physicals caused by changing the direction of plastic deformation is called the Bauschinger effect. Hardness tests easily measure the softening of metal due to this effect.

Deeper draws are possible in strip steels that are subjected to reversed deep drawing. This method of deep drawing often eliminates the need of intermediate heat treatment, which is usually required when deep drawing is done in one direction. It also has been observed that strip steel rolled in the same direction is harder than strip in which the direction of rolling is reversed after each pass. A study was made of the relationship of the Bauschinger effect upon the stress-strain relations when a metal is first deformed in one direction and then deformed with increasingly larger deformations in the opposite direction. The main physical test was the Vickers hardness test.

The Bauschinger Effect — In 1881 Bauschinger observed that the yield stress in tension and compression are dependent on the direction of working. For example, when a metal is elongated in tension its yield point is raised. The yield point will continue to increase with the application of additional plastic deformations by tension. However, if the metal is first subjected to elongation due to tension, and then a deformation applied by compression, the yield point is appreciably lowered. This effect has been observed in single crystals and polycrystalline metals. The effect is produced when tension follows compression or vice versa, or when torsion in one direction is followed by twisting in the opposite direction.

The changes which take place in the pattern of internal residual stresses (locked-up stresses) when

(Continued on p. 126)

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Softening Induced by Cold Working

(Continued from p. 124)

a metal is subjected to alternate plastic deformations of reversed sign is believed to explain the B-effect. As a rule, this effect is small in low-carbon steels, but much larger in high-carbon steels.

Rods of ⅜ to ⅝ in. diameter and 12 in. length were overstrained by tension, torsion, or by drawing through a die. These were then subjected to compression tests. Hardness changes were measured with a Vickers hardness tester.

The author found that for equal linear strains, the compression curves always were above the tension curves where the stress was plotted against strain. The opposite was found where the hardness was plotted against the strain (H-curves).

He points out that the difference in the work hardening values in tension and compression are actually larger than measured, in that the hardness tester itself contributes to the Bauschinger effect because a plastically deformed metal is indented by the diamond pyramid.

A maximum drop of 9 hardness points was observed in low-carbon steel. The steel was initially plastically deformed in tension followed by compression. The initial overstrain (in tension) was 5.7, 16 and 21%. A maximum softening of 25 points was observed in medium carbon steels (0.44 to 1.15% C). The 1.4% carbon steel exhibited a drop of only 16 points in hardness. This is considerably less than in the medium carbon steels, and may indicate that the Bauschinger effect is less in steels having a carbon content of over 1.2%.

Steels softened when they were deformed by torsion and then compressed. Also, the author found that nonferrous metals behaved like steel.

It was suggested by Masing that it should be possible to remove the Bauschinger effect by a low temperature heat treatment. In fact, it was believed that such a procedure should remove the residual stresses without changing the hardness. The author tested the theory advanced by Masing, using cold drawn phosphor bronze rod. His results failed to support the theory; the hardness values found after heating corresponded to alterations in the residual stresses. He also found that drastic aging of the steel prior to the compression treatment did not eliminate the work-softening effect.

It is well known that carbon and alloy steels in the quenched and tempered conditions are internally stressed. Such steels should work soften when subjected to cold working. Actual experimental tests showed that when 0.040-in. thick steel strip was hardened and tempered to Vickers 350 to 400 and then cold rolled by a series of light passes on a mill having small work rolls, the hardness dropped as much as 40 to 50 points. Similar effects have been observed by Armour, Adam, Goss and Brenner, and Andrew.

Polakowski then describes a mechanical model which pictures how stress-strain and energy are related during reversed deformation. It is suggested that the original paper be consulted; his analogy is easy to follow and adds much to the intrinsic value of his paper. The model appears to explain the facts, and in an intuitive way explains the relationship between the hardness and the latent energy due to cold work.

Discussion of Results — The experimental results obtained lead to the following conclusions:

1. A metal that is cold worked or quenched is strengthened, and systems of internal stresses are induced. These differ according to the way that the forces causing the strengthening are applied.

2. By applying a plastic deformation which is different from the one previously applied, a breakdown of the internal stresses results which decreases the internal energy of the deformed metal.

3. A decrease in the internal energy is responsible for work softening of the metal. The reduction in hardness and the increase in incipient temperature of recrystallization and elongation prove that work softening has occurred.

4. When a reverse deformation is applied to a metal, the deformation begins at a lower stress (Bauschinger effect). This is believed to be related to the decrease in deformation energy.

5. Cold working induces in steel a system of internal stresses, more or less different from those produced during a quenching operation. Therefore, cold working after quenching results in an equivalent to the Bauschinger effect. In a way this is reflected by the low stress value at which such steels take on a permanent set.

6. Tempering has the effect of raising the elastic limit and yield stress, which were lowered by pre-

(Continued on p. 128)

Softening Induced by Cold Working

(Continued from p. 127)
vious cold deformation or quenching. The author proved a very important point when he showed that the Bauschinger effect is not removed by aging.

7. For equal linear deformations, extension work hardens a metal to a greater extent than compression. This applies to steels and nonferrous metals that have a cubic lattice structure.

Sheets of cold rolled aluminum always recrystallized at a lower temperature when rolled in one direction than when cross rolled. The cross rolled sheets therefore responded to Bauschinger effect, and were work hardened to a lesser extent. Brick, Williamson, Bowles and Boas also found that cross rolled sheets were softer than when plastically deformed in the same direction. Trinks showed that straight rolled sheets contain more residual stresses than when the alternate passes through the mill are reversed in direction.

Brick and Williamson further observed that the effect of rolling directions was appreciable when 4-in. rolls were used, but negligible when the rolls were 14 in. in diameter. The argument that the reversing mill with small work rolls, having a low D/h (D, roll diameter; h, strip thickness), results in less work hardening for equal reductions appears to contain some truth.

It has been found that reverse deep-drawing makes it possible to make deeper draws, and in general fewer draws are required. The residual stresses are generally less, which reduces the possibility of cracking, usually attributed to age hardening. The Bauschinger effect is active in all deep-drawing operations, whether they are made in the same direction or the reversed direction.

The lesser degree of work hardening caused by reversed drawing lowers the yield point and at the same time lowers the residual stresses. This would make the effects of aging less drastic, and greatly reduce the chances of season cracking.

Conclusion — The evidence presented proves in a striking way that the Bauschinger effect is accompanied by a mechanical softening of the plastically deformed metal. Polakowski explains the changes in the internal energy and the residual
(Continued on p. 140)

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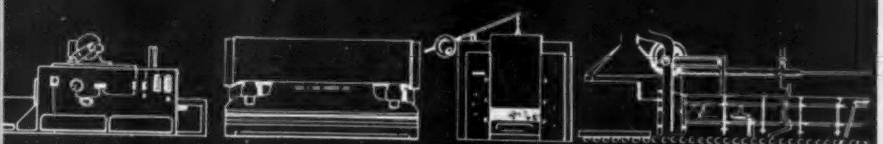

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Softening Induced by Cold Working

(Continued from p. 128)

stresses by a simplified mechanical model, which clearly illustrates how the forces interact when a metal is subjected to reversed plastic deformations, and how all of this is related to the Bauschinger effect.

This analysis appears to explain in a satisfactory way the reason why metals show a lower rate of work hardening when subjected to various forms of plastic working such as reversed cold rolling, cross rolling, reversed deep drawing, and when a quench tempered steel is subjected to plastic deformation.

N. P. Goss

Redefinition of "Strength of Materials"*

The author is extremely critical of the generally accepted system of strength of materials. He alleges that the subject matter as currently taught is neither unified nor rigid, but rather is incoherent and contradictory. The author has assumed the task of devising a new system to correct these conditions.

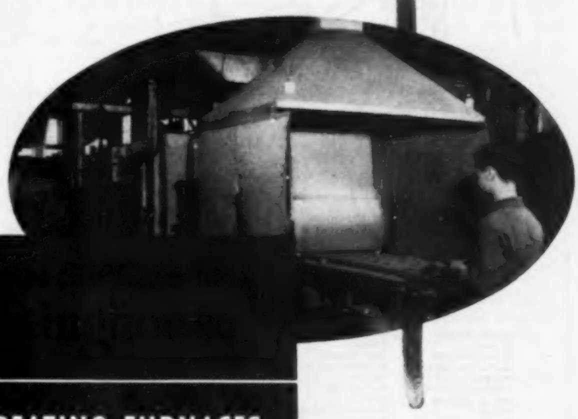
In current usage the term resistance can mean unit force, a ratio, or even an amount of energy (as in impact resistance). Strength has numerous meanings such as yield strength, ultimate strength, fracture strength, fatigue strength, and such. Hardness and strength are sometimes used as though they were nearly synonymous, but what does hardness really mean in terms of basic properties? Toughness, or its negative term brittleness, has a complex meaning that varies from one person to another. Toughness should be clearly defined in terms of mechanics; work is a fixed and simple thing which is easily understood. Ductility is defined one way and tested in another; it is often confused by the implication that softness is involved.

The author points out that in order to make further progress, a precise terminology should be adopted which would permit unequivocal if not mathematical interpretation of the terms involved.

In the proposed system, the author

(Continued on p. 142)

*Abstract of "A New Version of 'Strength of Materials'", by A. C. Vivian, *Metallurgia*, Vol. 45, January 1952, p. 29-37.



Redefinition of "Strength of Materials"

(Continued from p. 140)

contends that one suitable stress-strain curve is a complete statement of all mechanical properties of the elementary kind, while certain other properties — hardness, fatigue and notch toughness — are derivatives or compounds of such a curve. He discusses five obstacles to the acceptance of one true stress-strain curve. These are *(a)* the conceptions of properties such as elasticity, hardness and toughness in themselves are elementary values; *(b)* use of "nominal" type of stress-strain curve; *(c)* apparent or minor differences between tensile, compressive and torsion stress-strain curves; *(d)* current method of measuring strain; *(e)* all mechanical properties (for example, notch toughness) are not exhibited by even the ideal stress-strain curve.

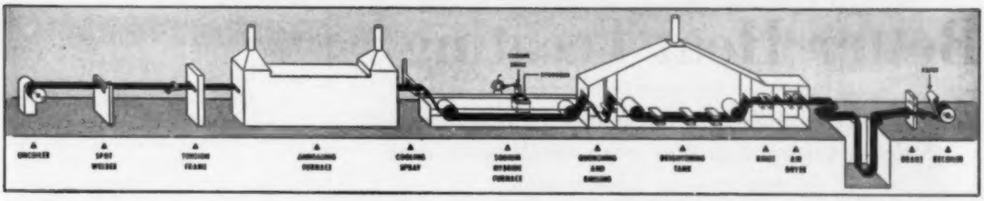
The author reasons that simple considerations of thermodynamics suggest that the amount of energy necessary to overcome the cohesion in, or to sever, a unit volume of metal must be the same whatever form of energy is employed. (It should be pointed out that this elementary logic is not necessarily correct; that is, an unnotched cylindrical bar of mild steel will break in a brittle manner if loaded in tension at liquid air temperature, but is extremely ductile when loaded in torsion.) The amount of energy required to melt a unit volume, expressed in work units, should represent the ideal true toughness. Variations in loading rate should alter the measured value of toughness because of thermal losses; high loading rates should be associated with lower energy.

Notch toughness is somewhat more complex; notch-tough material is one causing a spreading of the plastic flow beyond the notch. The author continues, a notch-sensitive material is one in which the spread of flow is inhibited on account of coarse grains, because of internal notches, or else because the metal contains some potential mechanical, physical or chemical energy by which it rips itself as soon as the high loading rate at the notch acts as a trigger to release that energy.

Hardness may be synthesized in a forthright manner from the stress-strain curve. On the other hand, fatigue failures which occur after many repetitions of stress, and con-

(Continued on p. 144)

Remove Scale CONTINUOUSLY with the Du Pont Sodium Hydride Descaling Process



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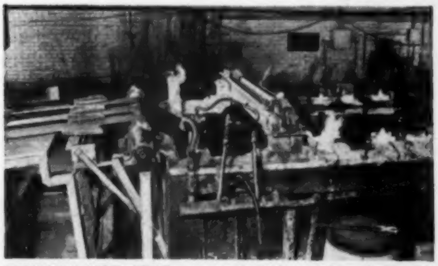

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- **UNIFORM DESCALING**—All surfaces are uniformly descaled without need for special racking procedures.
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- **NO LOSS OF BASE METAL**—Bath action is reducing. Reaction stops when oxygen is removed from scale, eliminating pickling losses, etching and pitting.

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Redefinition of "Strength of Materials"

(Continued from p. 142)
sequently differ markedly from the tensile test, cannot — the author admits — be correlated with the true stress-strain curve.

The one true stress-strain curve is the graph obtained on testing at room temperature and at a rate of loading which involves the fracture of the specimen in a minute or two. It is usually possible to apply a logarithmic formula to the curve shape.

Appended to the article is a short summary of the present style of defining and describing mechanical properties and the new style suggested by the author, based upon the true stress-strain curve.

E. R. Parker

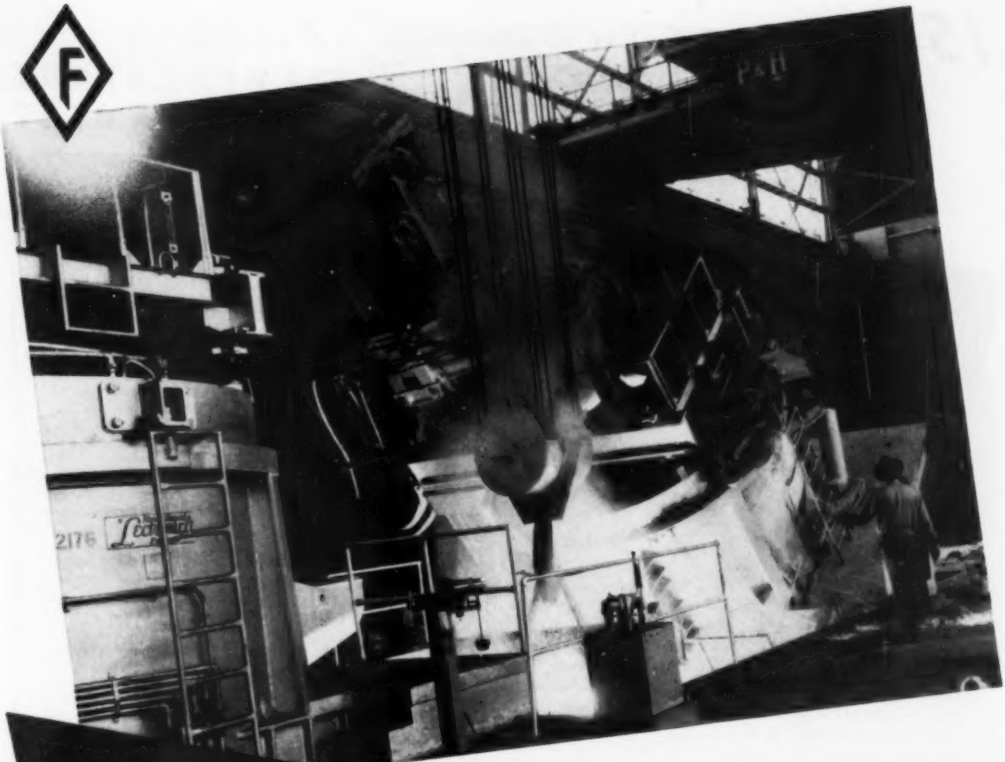
Flow of Liquid Metals on Solid Metal Surfaces*

This paper is a progress report of a long-term investigation by the British Nonferrous Metals Research Association. The object of the investigation has been to reach an understanding of some of the factors controlling the flow of liquid metals on solid metal surfaces, particularly as this flow affects the operations of soldering, brazing, and hot dipping.

The authors employed techniques involving the measurement of areas of spread of liquid metals on solid; the flooding of strips of solid metal by liquid, draining, and observing the stability of the coating; and the immersion of solid metal strips into liquid metals with observation of the several contact angles — that is, immersion, advancing (equilibrium), withdrawal, and receding (equilibrium). Experiments were performed in a hydrogen atmosphere with special apparatus as well as in liquid fluxes. Solid metals investigated were Cu, Fe, Ni, Au, and Ag; liquid metals were Ag, Sb, Te, Zn, Cd, Bi, Al, Sn, Pb, and Sn-Pb alloys. Considerable attention was paid to the system of Sn, Pb, and Sn-Pb alloys on Cu. Observations during these experiments were in terms of contact angle measurements, of the stability of resultant coating (wet-

(Continued on p. 146)

*Abstract of "The Flow of Liquid Metals on Solid Metal Surfaces and Its Relation to Soldering, Brazing, and Hot-Dip Coatings", by G. L. J. Bailey and H. C. Watkins, *Journal of the Institute of Metals*, Vol. 80, 1951-52, p. 57-76.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Flow of Liquid Metals on Solid Metal Surfaces

(Continued from p. 144)

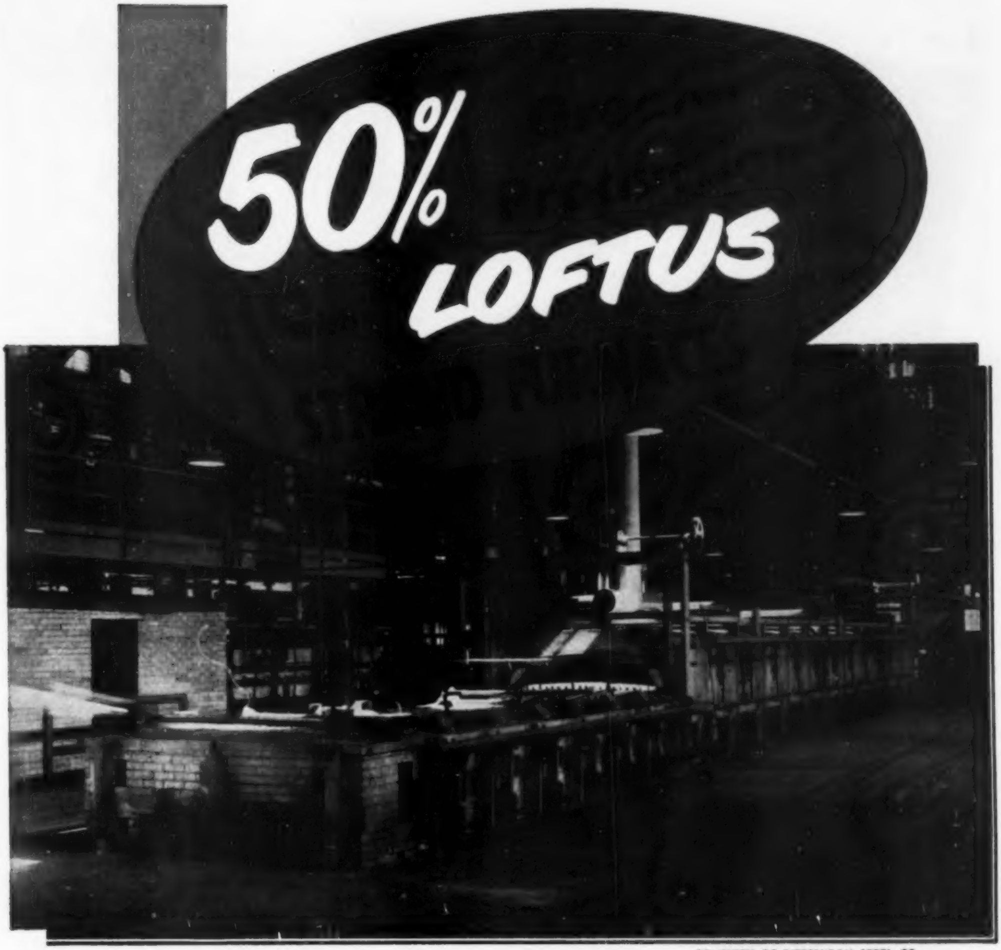
ted, dewetted, or nonwetting), and metallographic sections. An attempt was made to interpret the experimental results from the standpoint of certain derived theoretical concepts of contact angles, and relate these results to "practical" bit-soldering and capillary penetration observations.

A study of the area of spread of Sn-Pb drops on Cu in a H_2 atmosphere showed that enhanced (or secondary) spreading resides in the liquid metal. Flooding experiments indicated that the production of a stable coating was dependent on the tin content of the solder and controlled by the formation of the η-phase, Cu_6Sn_5. Immersion tests gave the clue that the lowest receding contact angle was also associated with the formation of this phase rather than that of the ε-phase, Cu_3Sn. The stability of the coating is proportional to the secondary spreading and there is marked contact angle hysteresis. The presence of diffusion bands, which are observed metallographically around Sn-Pb drops that spread on Cu at certain temperatures, is explained by the presence of the η-phase next to the drop and the ε-phase further out. The time and temperature required for a given Sn-Pb alloy to exhibit considerable secondary spreading is believed to be governed by the rate at which Sn can react with the Cu to form the stable η-phase. At the higher temperatures where secondary spreading does not occur, the lead in the solder competes for the tin and thereby delays the formation of this phase.

In the various experiments the particular contact angle measurement obtained was dependent on the extent to which diffusion had progressed. It was concluded that there is no single value of a contact angle for a given liquid metal on a given solid metal at any specific temperature.

The tendency of a liquid metal to spread over a solid metal is more pronounced with those liquid metal – solid metal systems that form solid solution alloys, is less pronounced with those systems that form intermetallic compounds, and is absent when the liquid metal is insoluble in the solid metal even though the solid metal may dissolve in the liquid metal.

(Continued on p. 148)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Flow of Liquid Metals on Solid Metal Surfaces

(Continued from p. 146)

While the occurrence of secondary or enhanced spreading resides primarily in the liquid metal, the rate of spreading is influenced by the flux. Thus in the Sn-Pb-Cu system the tin in the solder may be dissolved by and deposited from the zinc – ammonium chloride flux. This deposited layer permits the more ready spread of solder. The effect of electrochemical deposition from various fluxes was studied for the production of stable coatings of lead on copper and iron. It was established that, in general, when the e.m.f. of the cell Pb/flux/Cu (Fe) was about +0.1 v., a stable coating was produced. Independent experiments showed that real metallic deposits were obtained.

Stable lead coatings were not produced when Cu or Fe was immersed in pure Pb in a H_2 atmosphere in the absence of a liquid flux. However, when 0.1% Ni was added to the Pb, wetting took place supposedly by adsorption of Ni on the solid metal surface. Extension of the same reasoning to produce stable coatings of Sn on Cu or Fe using 0.1% Ni, and of Pb coatings on Cu using 2.5% Ag resulted in trials of only limited success.

Metallographic observation revealed that the formation of intermetallic compounds on the surface of Cu leads to roughening.

R. T. Foley

Creep Properties of Solution Treated N-155*

This report constitutes the first part of a continuing investigation of the fundamental factors that govern the high-temperature properties of austenitic alloys of the type used for aircraft propulsion systems. It is well known that variations in processing and heat treatment have pronounced effects on the high-temperature properties of austenitic alloys such as N-155. The behavior of such alloys is extremely complex. In order to develop better alloys, a scientific investigation is needed to reveal the factors

(Continued on p. 150)

*Abstract of "Fundamental Effects of Aging on Creep Properties of Solution Treated Low-Carbon N-155 Alloy", by D. N. Frey, J. W. Freeman and A. E. White, National Advisory Committee for Aeronautics, Technical Note 1001, 1950.

Creep Properties of Solution Treated N-155

(Continued from p. 148)

governing their high-temperature strength.

In this investigation it was assumed that the strength of the N-155 alloy was dependent upon the microstructure and lattice condition of the matrix. This report was concerned with the behavior of one alloy, low-carbon N-155 (0.13 C, 21 Cr, 19 Ni, 20 Co, 3 Mo, 2 W, 1.5 Mn, 1 Cb, 0.13 N). It was solution quenched from 2200° F. and then aged for various periods of time up to 1000 hr. at 1200, 1400 and 1600° F. The creep and rupture properties were determined at 1200° F. after these aging treatments. Creep tests were made at two stress levels, 30,000 and 60,000 psi., while rupture tests were made at 50,000, 60,000 and 70,000 psi. Changes in the microstructure produced by the aging treatments were followed by optical and electron microscopic techniques. The lattice conditions of the matrix, particularly the strains present, were measured by X-ray diffraction techniques. The microstructure and X-ray data were correlated with the creep and rupture properties. The investigation was necessarily limited in scope and consequently constitutes a report on techniques developed and progress to date.

The procedure employed was to age the solution treated stock at a selected temperature and time, then microstructural and X-ray diffraction studies were made to establish the structural characteristics of the material, then short duration creep and rupture tests were conducted at 1200° F. The investigation was intended to establish the relationship between creep-rupture properties and precipitation, particle size and distribution of the precipitated particles.

Aging treatments lasting 1, 10, 100, and 1000 hr. were conducted at each of the three temperatures 1200, 1400 and 1600° F. After aging, samples were prepared for optical and electron microscopic examination at 1000× by mechanical polishing followed by electrolytic etching. Formvar replicas were made of the surfaces studied under the light microscope. These were shadow cast with chromium and studied with an electron microscope at 8500×. The metallographic examination revealed that aging at 1200° F. resulted in slow but pro-

(Continued on p. 152)

Creep Properties of Solution Treated N-155

(Continued from p. 150)

gressive development of a distinct grain boundary constituent which resisted etching. After 10 hr. the precipitate was incomplete and did not surround all of the grains. After 1000 hr. the grains were completely surrounded with a band about 0.5 μ wide; also, slight precipitation was observed in the matrix near the grain boundaries. After aging at 1400° F. for 10 hr., the first separate boundary particles appeared; after 100 hr. the band widened to 0.8 μ; further aging caused little change in the grain boundary precipitate, but general matrix precipitation continued up to the 1000-hr. period. Concentration gradients appeared around the particles during the early stages of aging but seemed to disappear for times longer than 100 hr. Aging at 1600° F. resulted in the same types of reactions as those noted at 1400° F., except that they were accelerated, the boundary phase appearing after only 1 hr. of aging.

Strain-free surfaces were obtained for X-ray diffraction studies by electrolytically removing the surface layer. The etched samples were electropolished before X-ray examination. Line intensities were determined for the [111] line for all specimens, the unaged solution treated sample being used as a standard for comparison. Line intensities were found to decrease about 15% for short aging times and then to increase above the original value for long aging times.

The [111] line intensity measurements revealed no evidence of line broadening at any stage of aging; consequently, other lines were examined. The [220] line showed appreciable broadening, but only after long-time aging at 1400° F. A smaller amount of broadening occurred at 1600° F. after short aging times. The observed broadening could have been due to the presence of concentration gradients which formed in the matrix during precipitation, or it could have arisen because of the strains induced by the precipitation reaction. The actual cause was not established.

Lattice parameters were measured for all stages of aging. In general, a gradual decrease which continued for the longest aging times was observed. In some a small increase in lattice parameter was found for short aging periods.

(Continued on p. 154)

Creep Properties of Solution Treated N-155

(Continued from p. 152)

Hardness tests showed that substantial hardening occurred during aging. The specimens aged at 1400° F. showed the greatest effect, the Brinell hardness increasing from 185 to 250. Aging at 1600° F. caused a small increase, maximum values of about Brinell 200 being obtained. Aging at 1200° F. occurred so slowly that the hardness had increased to only 210 after 1000 hr.

Creep tests were conducted at 1200° F. and at only two stress levels, 30,000 and 60,000 psi. At the lower level, the creep rate was found to increase from about 10^{-5} in. per in. per hr. for the solution quenched state to 4×10^{-4} for specimens aged 1000 hr. at 1600° F. Behavior of specimens aged at 1400° F. was similar with only slightly smaller effects. Aging at 1200° F., however, caused no substantial change in creep characteristics. Tests at the 60,000-psi. stress level were conducted on only those materials aged at 1400 and 1600° F. Results from both series were essentially the same. The creep rate decreased to about half with short aging times and thereafter rose steadily, reaching a value of twice that of the solution quenched specimens at the 1000-hr. aging time.

Rupture tests were conducted at three stress levels, 50,000, 60,000 and 70,000 psi. at 1200° F. Only two highest aging temperatures were investigated. The results were essentially parallel at all stress levels, the effect of higher stress being to reduce the life. For the specimens aged at 1400° F., the rupture life increased with aging up to about 100 hr. and thereafter remained essentially constant. A similar behavior was found for the specimens aged at 1600° F., with the life increasing with aging up to about 7 hr. and thereafter remaining constant.

The conclusions drawn are:

1. Aging of solution treated N-155 caused a lowering of the short-time creep strength but markedly increased the rupture time. This resulted in greater fracture ductility for aged specimens.

2. Aging removed atoms from solid solution by promoting precipitation. No optimum dispersion of precipitate was found. Aging induced grain boundary precipitation. Whenever the grain boundary phase formed, grain boundary failure was retarded.

E. R. Parker

Neutralization of Waste Pickle Liquor*

TREMENDOUS UPSURGE in the production of flat-rolled steel in the U. S. over the past 20 years has complicated a vexing mill problem — disposal of waste pickling liquors. Last year, for example, steel plants turned out a total of 5,500,000 tons of tin, terne and black plate, plus approximately 13,700,000 tons of full finished sheets and strip and flat galvanized products. How much waste pickle liquor was produced in these operations is difficult to figure, but one estimate puts it close to a billion gallons for the year.

This enormous volume of waste, essentially a solution of ferrous sulphate and sulphuric acid, has been the subject of continuous and unrelenting research in the effort to find a suitable means for conversion or recovery of chemical values, or for neutralization and disposal. The latter has become increasingly critical in view of the pressures which government agencies are exerting on industry to stop rejection of wastes which could lead to stream pollution and its harmful effect on fish and wild life.

In 1938 the American Iron and Steel Institute, through its Stream Pollution Committee, established a multiple industrial fellowship at Mellon Institute, Pittsburgh, for concentrated study of the problem. Literature from this research program, as well as from others in this country and abroad, has been prolific and varied, although as yet it has led to no firm solution of the problem.

World shortage of sulphur has led to renewed interest in the manufacture of sulphuric acid from the ferrous sulphate of pickling wastes. It is entirely practicable, although cost of the equipment and its maintenance is high. Economics appear to dictate a plant which will produce a minimum of 100 tons of concentrated acid daily, and no single steel mill produced pickle liquor in volume to sustain such an output. Thus, it would have to be a cooperative enterprise, raising a whole host of new difficulties. *(Cont. on p. 160)*

*Abstract of "Acid Iron Wastes Neutralization", by Richard D. Hoak, *Sewage and Industrial Wastes*, Vol. 22, February 1950, p. 212. Corollary information by same author in *Industrial and Engineering Chemistry*, Vol. 39, February 1947, p. 131; Vol. 39, May 1947, p. 614; Vol. 40, November 1948, p. 2062. See also *Sewage Works Journal*, Vol. 17, September 1945, p. 940.

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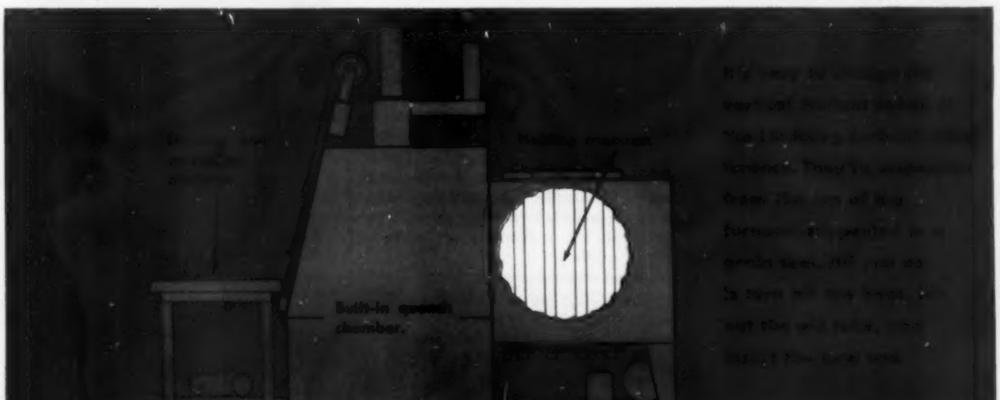

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Neutralization of Waste Pickle Liquor

(Continued from p. 156)

Neutralization is a costly procedure, both in terms of the necessary alkaline material and the expense involved in disposing of sludge. Other considerations are reactivity and availability of alkaline agents, space available for the neutralization plant and sludge storage, anticipated volume and composition of pickle liquor and rinse water, pickling shop operating schedule, neutralization techniques, provision for discharge of effluent, and perhaps some peculiar local conditions which may affect the project. The least expensive alkali at hand may not prove the best in terms of over-all economy, since alkalinity and reactivity are important. High-calcium quicklime finds extensive use for neutralization.

A number of neutralization processes are available and must be evaluated carefully in terms of local conditions. One, of course, involves the need for a storage lagoon into which slurry may be discharged. Where limited or no lagoon space is available, there is a new process which depends on controlled oxidation of the iron, in the presence of an alkaline agent, to ferrosoferric oxide. It is simple to operate, requires feeding the pickle liquor at a predetermined constant rate to a bath in a reactor in which the temperature is maintained above 165° F. and means are provided for efficient aeration.

Successful operation is linked principally to balancing the rate of iron precipitation with the rate of oxidation of ferrous hydrate. These rates must be controlled so that the iron in the precipitate will have a ferric-to-ferrous ratio between 2 and 5, while the temperature of the bath is maintained high enough to promote the formation of ferrosoferric oxide.

Over 100 pilot plant tests, using several different alkaline agents, seem to prove the practicability of the method. Most significant feature is the rapid rate of slurry subsidence — complete in 15 to 30 min. under normal conditions. Final sludge volume also is relatively small. Slurry can be filtered at a high rate on a vacuum filter—400 lb. of wet cake per sq.ft. per hr., the cake containing 60% dry solids — or about 20 times what can be done with slurry from conventional neutralization.

A. H. Allen

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High-Temperature Aluminum Alloy*

AN ALLOY of aluminum and mischmetal (50% cerium and the rest the other rare earths, including lanthanum) shows considerable promise as a high-temperature alloy in comparison with the conventional age hardening aluminum alloys which are seemingly limited in long-time use to 600° F. and less. After a number of possibilities were screened by a "stepped load test", the following was accepted as optimum and investigated at length: 11% mischmetal, 2% silicon, 1.5% copper, 1.25% nickel, 1.0% manganese, 0.3% chromium, 0.02% titanium, balance aluminum. The natural mixture of rare earths seemed to be desirable, since a similar alloy made with commercially pure cerium did not have such good high-temperature properties.

To avoid the tendency of segregation, all melts were made in induction heats and graphite crucible, and the current kept on to the very end and the metal poured within a few seconds after leaving the induction coil. Master alloys of high purity, plus ingot metal, were melted; the mischmetal was then added slowly in small pieces; then dried nitrogen (dew point −80° F.) passed through melt; then the aluminum-silicon and the aluminum-titanium alloys added, and finally dried nitrogen passed through the melt for 5 min., the melt being at 1400° F. or higher.

Metal was then poured into vertical cast iron chill molds with a hot-top of baked core sand, forming a star-shaped ingot 6 in. high. From each wing of this ingot 4 tensile specimens and 2 stress-rupture specimens were cut, and the center retained for forging experiment.

Under the melting conditions described, there was practically no melting loss of the mischmetal. Fluidity tests showed that minimum casting temperature should be 1400° F., and 1500 for thin sections. Casting temperatures can go to 1800° F. without harm to the high-temperature strength. Furthermore, there seems to be no difference in this respect between chilled castings and sand castings. In general, this SAM (special aluminum mischmetal) alloy can be successfully

(Continued on p. 164)

*"A Mischmetal Aluminum Alloy for Elevated Temperature Service", by B. M. Loring, W. H. Baer, and C. G. Ackerlind. Naval Research Laboratory Report 3871, Nov. 1, 1951.

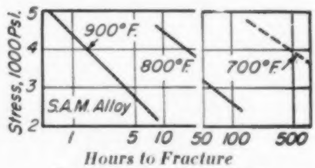
High-Temperature Aluminum Alloy

(Continued from p. 162)

handled by the same molding and foundry techniques as the 7.5% silicon-aluminum alloy, except for temperature of casting.

The SAM alloy forges easily at 1100° F., and the as-cast elongation of 0.5% is thereby increased to 10%; the Vickers hardness as-cast of 52 is increased to 62 as-forged, but the creep strength is reduced drastically. This is probably due to the fine interlocking acicular structure of the casting, and forging fragments this microstructure badly. Furthermore, changes in composition which alter this interlocking acicular structure also reduce drastically the high-temperature strength.

Annealing temperature for forged and rolled SAM alloy is 1100° F.; by a series of annealings and rollings at 1100° F., sheets of 0.10-in. thickness have been produced. Stress relieving for forged or rolled alloy is 800 to 1000° F. (It will be noted that treatments are similar for all the other high strength aluminum alloys, except that the temperatures are higher.)



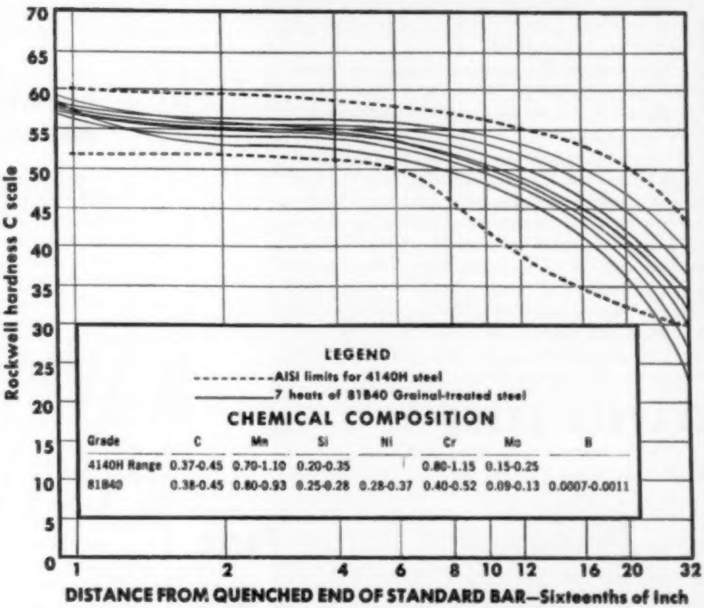
Hours to Fracture
Summary of Stress-Rupture Test for SAM Alloy

The diagram summarizes the stress-rupture properties, and it will be seen that they are on an entirely different order of magnitude from the age-hardening aluminum alloys which have been studied in the lower ranges of temperatures. For example, in comparison with the "Y" alloy (the usual high-temperature alloy of aluminum containing 3.9% copper, 1.5% nickel, and 1.5% magnesium) we have the following:

	"Y" Alloy	"SAM" Alloy
Room temperature		
Ultimate strength	29,000	15,000
Elongation	1.0	1.0
Short-time tensile tests at 800° F.		
Ultimate strength	5,500	9,000
Elongation	80.0	2.0
Time to fracture under 4000 psi. at 800° F.	1 min. max.	9 to 40 hr.

(Continued on p. 166)

STANDARD (END QUENCH) HARDENABILITY CHART—



Grade	C	Mn	Si	Ni	Cr	Mo	B
4140H Range	0.37-0.45	0.70-1.10	0.20-0.35		0.80-1.15	0.15-0.25	
81B40	0.38-0.45	0.80-0.93	0.25-0.28	0.28-0.37	0.40-0.52	0.09-0.13	0.0007-0.0011

Consistent Hardenability obtained in Boron Steels made with GRAINAL ALLOYS

The most common test for boron steels is measurement of hardenability by the end quench or Jominy hardenability test. Today's steel substitutions are made on the basis of similar hardenability since a reasonable prediction can thus be made of the hardness and strength of a given part.

The curves above show the relationship between the hardenability of a series of seven heats of 81B40 steel and the hardenability band for 4140H steel, which it often replaces. The 81B40 heats were made in one electric furnace shop, and the remarkably consistent hardenability shown by the curves was obtained by the use of Grainal alloy as the means of adding the boron.

Consistent hardenability means consistent strength and hardness after heat treatment, which is the aim of every fabricator. The best proof that the Grainal alloys insure this objective is found in the successful use of three million tons of Grainal-treated steels.

High-Temperature Aluminum Alloy

(Continued from p. 164)

Although the SAM alloy appears to be distinctly inferior in room temperature testing, it is markedly superior in short-time tests at 800° F., and in an entirely different category as far as its much longer time to fracture is concerned.

Improved Finish for Magnesium Alloys*

A SPECIAL ELECTROLYTIC PROCESS for surface treatment of all magnesium alloys, developed by Harry A. Evangelides of Frankford Arsenal, has shown some exceptional results in terms of resistance to corrosion and wear. It is identified as the HAE treatment and is available at present only for military applications. The electrochemical bath has good throwing power and produces a refractory ceramic coating varying in thickness from 0.001 to 0.0015 in. and hard enough to scratch glass, or between 7 and 8 on the Mohs scale.

Texture is such that an excellent base for paint or wax is provided. A waxed HAE-treated magnesium test panel continuously exposed to salt spray has already accumulated 8000 hr. with no trace of corrosion. Absolute protection of 800 to 1000 hr. has been obtained from similar panels dipped in a 15% wax solution in toluene.

Exceptional resistance to galvanic corrosion is made possible since a thickness of 0.001 in. will resist an electrical potential of 550 volts at 60 cycles. Abrasion data obtained on a Tamer Abraser showed no breakdown after 8000 cycles, against breakdown after only five cycles with a specimen having a dichromate and galvanic anodize treatment.

Loss of tensile strength of HAE-treated specimens of 0.022-in. thickness is 8%, largely due to loss of magnesium metal in conversion to the coating. Its relatively inelastic nature does not favor flexure.

Items which have been treated experimentally include magnesium propellers, rocket launchers, aircraft camera cases, jet engine components and structural components of aircraft frames.

*Abstract of "A New Finish for Magnesium Alloys", by Harry A. Evangelides, *Organic Finishing*, Vol. 12, October 1951, p. 17.

Plating Aluminum With Nickel*

FAILURE of the usual mineral acid and alkaline etchants to bring the surface of aluminum into condition for nickel plating has been due to incomplete removal of surface film and possibly the formation of secondary films which interfere with plating. Trichloroacetic acid overcomes these difficulties, although it is expensive for commercial use. Modification of the etchant from an 88 to 5% concentration, using an addition of 25% phosphoric acid, has improved the economy.

Another objection is the danger involved in washing the etchant with acetone, as originally proposed. This is corrected by dipping in nitric acid as an oxidizing agent before washing with water to prevent the evolution of hydrogen which would otherwise occur, even in the plating solution. In this way, improved adhesion of the nickel coating is realized without the need for using acetone.

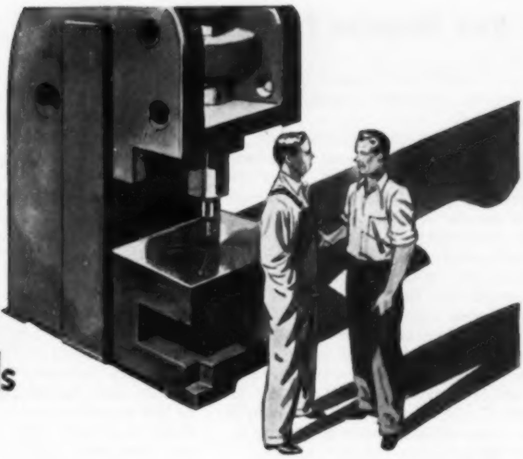
Etching is carried out for 1 min. at 167° F., followed by a 15-sec. dip in nitric acid of 1 : 4 concentration and a water wash. Direct plating is done at a current density of 15 amp. per sq.ft. in 1 hr. 20 min. and in a bath of 120 g. $NiSO_4 \cdot 7 H_2O$, 21 g. $(NH_4)_2SO_4$, 8 g. KCl and water to 1 liter held at 95° F., and between 5.6 and 5.8 pH.

Applications of nickel-plated aluminum are seen in the food processing industries, where the lower cost and easier fabrication of aluminum as against stainless steel would prove attractive. Nickel-plated aluminum is more easily cleaned than plain aluminum and, if given a chromium flash, has a high appearance value, suggesting possibilities in the dairy and brewing industries. Where lightness is a factor, plated aluminum alloys could meet favorable reception.

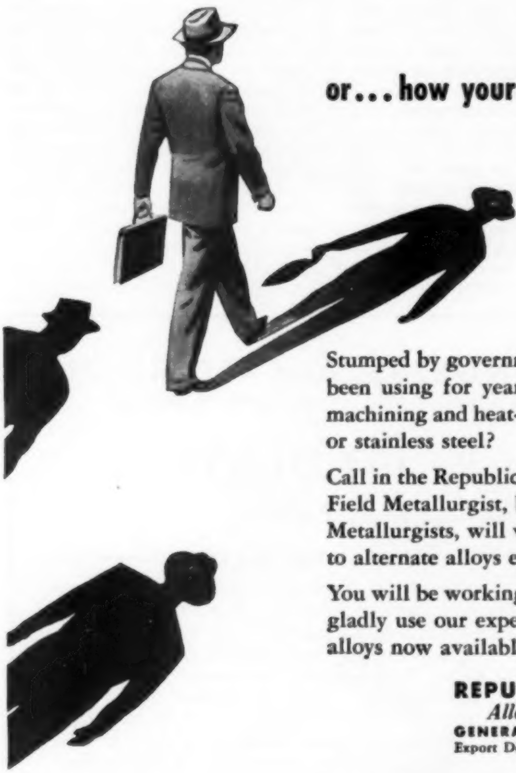
Practicability of the process has yet to be proved, although laboratory studies seem to indicate the desirability of tests on a commercial scale. Further laboratory investigation is planned to compare the corrosion resistance of directly plated specimens with others plated by the sodium zincate process with and without a copper undercoating.

A. H. ALLEN

*Abstract of "Plating Aluminum With Nickel", by A. G. Thomson, *Metallurgia*, Vol. 44, December 1951, p. 308.



a few words about alloy steels



or... how your alternate steel problems can profit

from a Republic Suggestion

Stumped by government restrictions on the alloy steel grades you've been using for years? Faced with the problem of working out machining and heat-treating procedures on alternate alloys... carbon or stainless steel?

Call in the Republic 3-Dimension Metallurgical Service. A Republic Field Metallurgist, backed up by the Republic Mill and Laboratory Metallurgists, will work with your metallurgist to make the switch to alternate alloys easier.

You will be working with the leading producer of alloy steels. We'll gladly use our experience to help you get all the benefits from the alloys now available.

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Republic ALLOY STEELS

Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Plates, Pipe, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

Hard Chromium Plate

(Continued from p. 78)

using a current density of 350 amp/sq.ft.

The most pronounced effect of chromium plating was to reduce the plastic deformation prior to fracture in all types of tests except the tensile impact. The reduction of elongation in tensile tests was particularly noticeable. Tensile and yield strengths of plated steel decreased as the thickness of the chromium was increased from 0.001 to 0.015 in.; steel plated 0.015 in. thick showed 91% or more of the corresponding properties of the unplated steel. Baking at 200 to 400° C. (390 to 750° F.) for 6 to 8 hr. substantially increased the plastic deformation before fracture.

Heat treatment is important to a number of applications of chromium plating, notably plated tools. Additional life ranging from two to ten times the normal life of unplated tools has been obtained when they are properly plated and heat treated. Good results have been obtained with cutting tools by heat treating at 600° C. (1100° F., or higher, depending on the steel) to stress-relieve prior to chromium plating. After plating for an average period of about 5 min., the plated tool is again stress-relieved by heating in air or oil at 350° F. for 1 to 3 hr.

A special type of chromium plate, known as "porous chromium", is produced by selective etching of surface cracks to give an oil retentive surface. Thus, the poor wetting characteristics of chromium plate are counteracted, while the good properties of the plate are unimpaired. So-called "Locontraction" chromium plate is deposited at elevated temperatures, and was described in 1945 by G. E. Gardam in the *Journal* of the Electrodepositors' Technical Society, Vol. 20, p. 69, as having relatively few cracks and exceptional resistance to hot corrosive gases. Another variety is a high-speed process used for steel plant maintenance. Characteristic are high current densities and a chromic acid bath containing a high concentration of sulphate radical at high temperature. One of several acceptable baths recommended by R. M. Wick of Bethlehem Steel Co., in *Iron and Steel Engineer* for December 1948, contains 257 g/l. of chromic acid and 5 g/l. of sulphuric acid, and is operated at 160° F. Current densities of 1000 to 3000 or more amp/sq.ft. produce good properties.

DECORATIVE USES

The pleasing blue-white color, superior hardness, and the useful oxidation and tarnish resistance of chromium plate are the main reasons for its wide application in decorative uses. The chromium is generally applied as a thin final deposit over a much heavier bright or buffed nickel plate. Copper plating is widely used on steel and die castings as an undercoating for the nickel-chromium finish.

At the 1952 Annual Educational Session of the Philadelphia Branch, American Electroplaters' Society, C. F. Nixon of General Motors Corp. discussed decorative finishes which are being considered as a result of the nickel shortage. One plating cycle consists of heavy copper, low nickel, then chromium followed by lacquer. In this cycle 0.0003 to 0.0005 in. of nickel is applied over copper plate to give a total thickness of 0.0015 in. for out-of-doors; the nickel thickness for indoor use is 0.0002 to 0.0003 in. Chromium is then applied over the copper-nickel.

Two decorative chromium finishes were suggested by Nixon which require the use of no nickel undercoat: One cycle consists of copper plate followed by chro-

(Continued on p. 172)


"line one - for you"
If you're an Inland customer, that's probably your service man calling to report the status of your steel order.
As a customer at Inland, you have your own service specialist—who expedites your orders and keeps you posted on production progress.
INLAND STEEL COMPANY
38 South Dearborn Street, Chicago 3, Illinois
INLAND

Hard Chromium Plate

(Continued from p. 170)
mium and lacquer. The other was copper flash, followed by a white brass plate, then chromium and lacquer. White brass plating was discussed at length by Webster B. Knight in *Metal Progress* for March.

As a substitute finish for decorative chromium, zinc plate followed by a chromate bright dip and lacquer is being used on steel and on zinc-base die castings. However, the color of this finish differs somewhat from that of chromium.

Chromium plate normally has a very thin transparent oxide film on its surface, which is so stable, tenacious, refractory and self-healing that it protects the metal underneath from further oxidation. The plate remains bright at temperatures up to 500° F., but on prolonged heating in air at higher temperatures the oxide film grows in thickness and darkens. The chromium oxide is also a satisfactory protection against sulphides which tarnish silver, copper or nickel at normal atmospheric temperatures.

In thicknesses greater than about 0.0005 to 0.001 in., chromium plate protects against many other types of corrosive environments. Although it is attacked by mineral acids and certain reducing solutions, it is strongly resistant to nitric acid, which heals the protective oxide film. The deposit should be sufficiently thick to insure that the cracks in the plate are not continuous to the basis metal.

In general, at ordinary temperatures chromium plate of proper thickness may be applied in the same types of service as the high-chromium stainless steels. Substitution depends to a considerable extent on the physical properties required of the basis metal.

CHROMIUM-PLATED DIE CASTINGS

At a symposium on "Electrodeposition Researches in Progress" held recently at the National Bureau of Standards, M. R. Caldwell, L. B. Sperry, H. K. DeLong, and L. M. Morse gave an account of a cooperative program conducted by three companies to determine the necessary thickness of plating to be used on aluminum and magnesium-base die castings. Approximately 720 panels, 4 x 6 in., were plated with copper-nickel-chromium and exposed in Detroit, Coraopolis, Pa., Miami Beach, Fla., and Grand Rapids, Mich. About one third were zinc die castings, included for controls, and the remainder divided among three common alloys of aluminum or magnesium.

These corrosion tests indicated that at least 0.002 in. of copper and nickel was necessary to provide adequate protection of aluminum-base die castings against outdoor corrosion for one year in the severe locations. On zinc-base die casting, 0.00125 in. gave fair protection, and the additional protection produced by going to 0.002 in. was comparatively small. There was little correlation between salt-spray results and exposure tests.

Exposure tests showed that each base metal had a characteristic type of corrosion. Magnesium was deeply pitted, particularly at the seacoast. The plated zinc control panels were covered with a much larger number of smaller sized pits. Aluminum showed spreading corrosion at the interface in both industrial and seacoast exposures. In the last analysis, the corrosion of the plated zinc was not as objectionable as that of the aluminum or magnesium die castings.

AIMED AT BETTER ROLLING
MIDVALE HARDENED AND GROUND FORGED STEEL MILL ROLLS
Forged steel rolls have been a Midvale specialty for many years, but every new one made is aimed at doing a better job than ever before. Skill and experience of Midvale craftsmen assure rolls built to your most exacting specifications of hardness and finish. Modern equipment and quality control —from furnace to finished roll—produce rolls unsurpassed in quality and performance.
Whatever your needs for heavy equipment in industry Midvale can assure you of precision and performance. Whether it is a roll for your mill . . . roll shells for mining and cement industry . . . pressure vessels for the chemical and petroleum industries . . . rings for turbines and gears . . . or castings and forgings for any industry . . . Midvale can make them to your most exacting specifications.
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Custom Steel Makers to Industry
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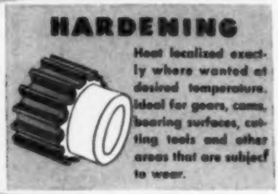
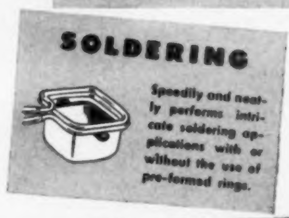
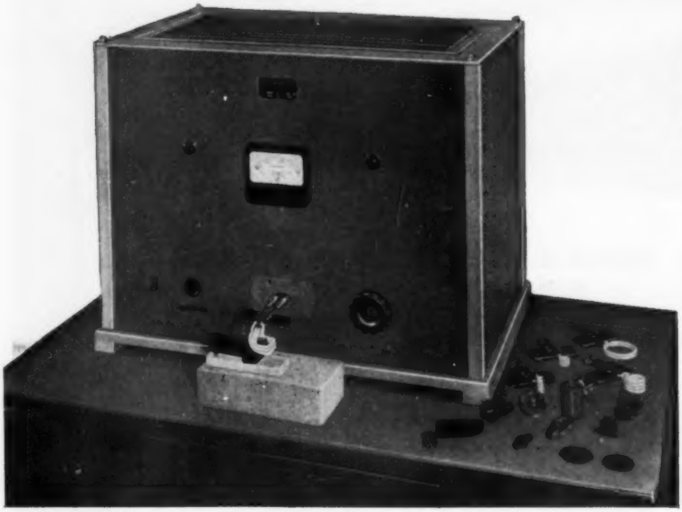
Lepel *presents*

A *Low Cost* PORTABLE HIGH FREQUENCY *Induction* HEATING UNIT







- **SMALL AND COMPACT**
  Conveniently operated on bench or table—no mounting necessary.
- **ECONOMICAL OPERATION**
  No special power installation required. Operates on 110 volts, 60 or 50 cycle line at unity power factor.
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  Guaranteed for continuous duty cycle and stated performance.

This versatile unit is priced so low that every shop may now take advantage of modern induction heating techniques to improve quality and to increase production. Its simplicity of operation eliminates the need for skilled personnel.

The Lepel Model 2 KW will meet the requirements of machine shops, toolrooms, research laboratories and educational institutions. It is especially suitable for hardening, brazing and soldering small parts of either ferrous or non-ferrous metals.

Complete unit with line connection and load coil.

$870.
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WILL HEAT TO 1500° F.

⅛" steel rod 1" length in approx.	1 second
¼" " " " " " "	3 seconds
½" " " " " " "	15 seconds
1" " " " " " "	60 seconds

Will melt 4 ounces of brass or steel in 4 minutes.
Equally well suited for heating of non-ferrous metals.

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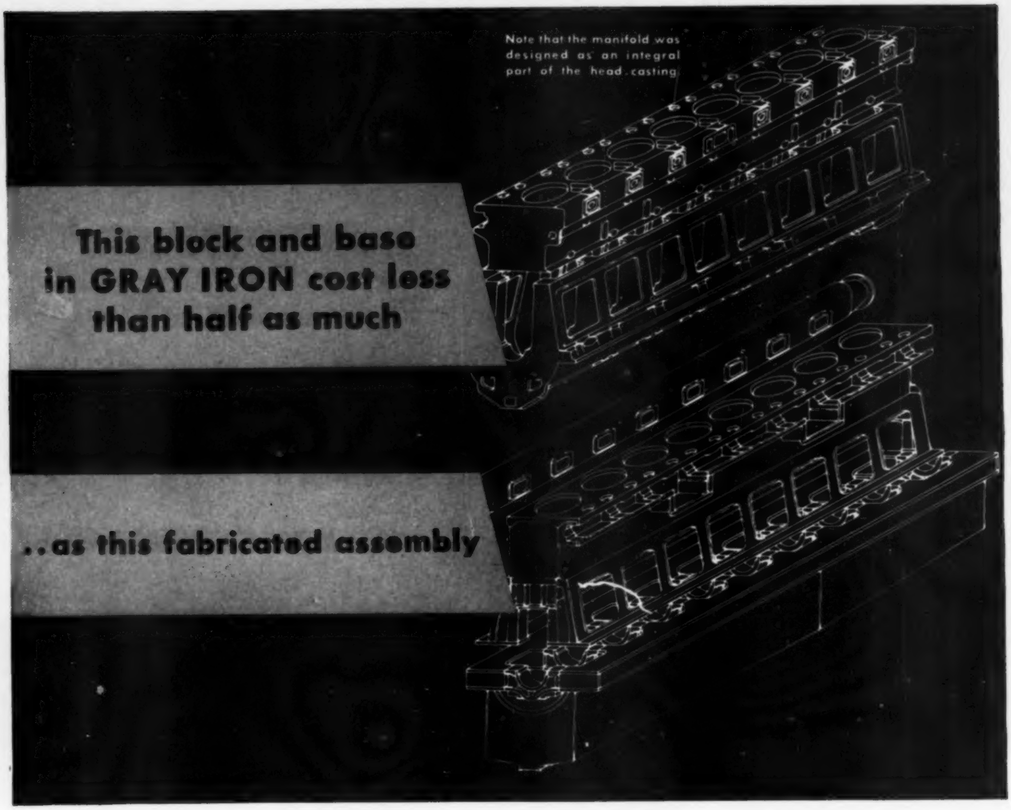
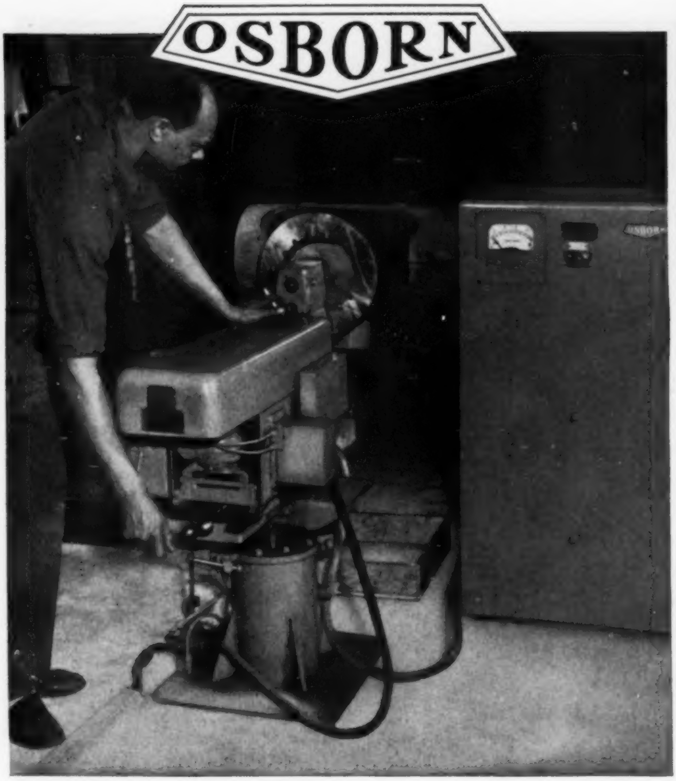
Write for Lepel Catalog MP-6


Note that the manifold was designed as an integral part of the head casting
This block and base in GRAY IRON cost less than half as much
..as this fabricated assembly



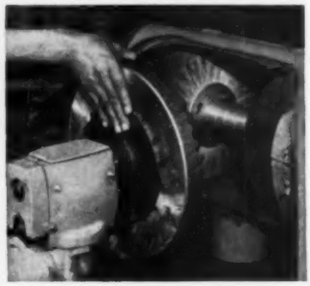
Deburrs gears 15 times faster at the push of a button!

Want to break a big bottleneck in the production of gears and similar parts? Manufacturers are doing just that with the Osborn Work Holder Brushing Lathe.

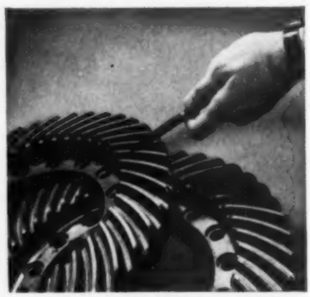
In the plant of the White Motor Company, Truck Division, Cleveland, Ohio, this Osborn machine deburrs and finishes gear teeth 1570% faster than the old method. This was done formerly with a portable grinder . . . a tedious operation that took 25 minutes for the 14-inch hypoid gears shown. Now, an operator simply places the gear in the Osborn Work Holder Brushing Lathe, pushes a button and the machine does the job automatically. Floor-to-floor time is only 1½ minutes! Uniformity of finish results in additional time savings in matching and assembly of gears.

It will pay you to investigate this high-speed, high-quality machine for deburring and finishing gears on a production basis. Call your **Osborn Brushing Analyst** today or write *The Osborn Manufacturing Company, Dept. 737, 5401 Hamilton Avenue, Cleveland 14, Ohio.*

SET-UP IS SIMPLE. The machine is versatile. If your production involves small runs of many different types and sizes of gears and similar parts, you can specify machine settings for each part and operator can make set-up changes easily and quickly for maximum daily output. The complete brushing cycle is controlled automatically by the electronic timer which is set for any desired brushing interval to suit the size, shape or condition of part being brushed.



OPERATION IS SPEEDY. The operator mounts the gear easily and quickly. The gear advances to the face of two rotating Osborn brushes and the edge of the gear teeth makes contact with the brushes. To assure fast, positive action on each piece brushed, an automatic control reverses the direction of brush rotation on every cycle of operation.



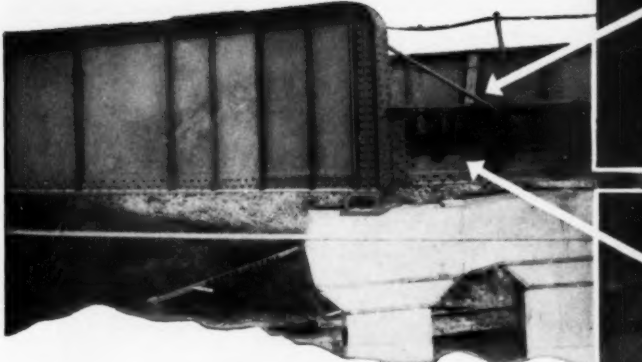
RESULTS ARE UNIFORM. Burrs and sharp edges are removed uniformly. Every gear tooth has smooth, uniform rounded edges. Surfaces are blended.

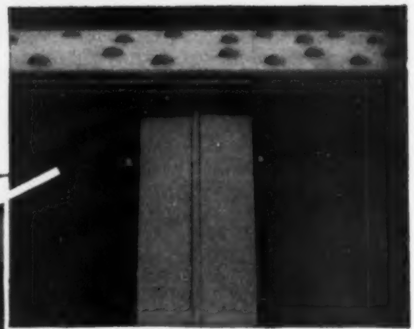
INVESTIGATE IT TODAY

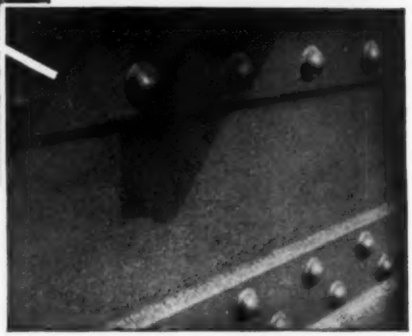
for *your* problems. Users report time savings ranging from 20% to 1570% with the Osborn Work Holder Brushing Lathe. Let us demonstrate what it can do for you!

Osborn Brushes

OSBORN POWER, MAINTENANCE AND PAINT BRUSHES AND FOUNDRY MOLDING MACHINES



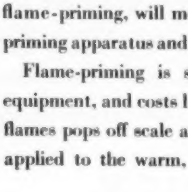




All steelwork on this bridge was flame-primed before paint was applied. Today, after 9 years' service, the original paint job still provides complete protection against corrosion. Present condition of surfaces is clearly shown by unretouched close-ups.

Your Steelwork . . .

How Will It Look in 1960?



Steelwork you coat with good paint today can still look like new ten years from now, *if you flame-prime all exposed surfaces first.* And what you'll save on maintenance, because of increased protection due to flame-priming, will more than pay for all the flame-priming apparatus and materials you need for the job.

Flame-priming is simple to do, requires little equipment, and costs little. A brush of oxy-acetylene flames pops off scale and drives out moisture. Paint applied to the warm, dry surface goes on quickly and smoothly, bonds tightly, and lasts longer.

Flame-priming is one of many time- and money-saving LINDE methods for making, cutting, joining, treating, and forming metals. So, whatever you do with metals, there is a good chance that LINDE know-how, show-how, and equipment can help you do it better, more quickly, or at lower cost.

To find out, without obligation, telephone or write our nearest office today. LINDE AIR PRODUCTS COMPANY, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in Other Principal Cities. In Canada: Dominion Oxygen Company, Limited, Toronto.

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Q-ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION **X-ite**

...WITH MANY IN HIS DEBT

On April 14, Mike Graham died—on his feet and with his mind's eye on horizons which, like many milestones in his vigorous life, he had *plotted well* and planned to cross. Mike was Director of Manufacturing for International Harvester Co. He came up through the ranks, progressed by seeking opportunity, accepting responsibility, and *delivering*, from office boy to toolmaker and up! Through each progressive step of operation and administration, he kept *learning*, and *teaching*. "Teach your boys to do your job well, and you keep moving forward."

Mike was both product and progenitor of a century-old policy of man-building. Harvester's top quality product is *MEN*. *Teamwork* is paramount, building *scores* rather than *stars*. Many men, advancing through Mike's aid, in his footsteps, will revere and project his concept of *loyalty to the vision of work well done*. More than thirty years ago, Mike, pioneering as always, bought the first "expensive" Q-alloys to replace "cheap" iron pots. "If you deliver, you're in. If you don't, you're out," said Mike—sound philosophy applied to metals, and to men.

Mike made everything from magnetos and roller bearings to cotton pickers and Naval torpedoes—functional, dependable, top-quality products that produce the Nation's food and that fought in three wars. Mike had strong loyalties and strong friendships, inside and outside of an organization unique in the loyalty of its customers and suppliers. Mike was proudest of building those versatile small tractors, "that help the little guy plant more seed, harvest more crops, *and get ahead* . . . . He's the guts of the American system." As one of the "little guys" whom Mike helped to get ahead, I am proud that I and my "boys" have had the privilege of Mike Graham's friendship and the deeply satisfying experience of working with him through the years.

HHHarris

M. J. "Mike" Graham
1892–1952

LETTER FROM KOREA

1 May 1952

Dear folks:

Now that I have the urge to write I find very little to write about. The war goes on, apparently interminably, although there are signs at times which indicate that it might end some day. We watch the news sheets daily, hoping almost against hope that something definite will come out of the peace talks, but the futility of it strikes us more often than the hopefulness. I suppose that this condition could go on for years; as long as no real war is being conducted there is probably no real hope for peace. I am constantly upset about fatalities, there seems to be so little to gain by the loss of a life now. In addition, it is difficult to read about the steel strikes, the auto strikes, the railroad strikes, the communications strikes, and all the rest without being slightly bitter. It is hard, at times, to convince myself that the fighting here will ever accomplish anything at all.

There seems to be no honorable way to settle the war without engaging in further all-out war effort. As long as the pressure is taken off of the communists they have nothing to gain by agreeing to an armistice. In addition, the prisoner exchange is a real monkey wrench. I suppose that the people in the States feel that we should turn the prisoners back to the Reds and forget about them, and, in all probability, political pressure will finally demand just that. The incongruity of that should be obvious. We are, theoretically at least and certainly in the eyes of the Koreans, fighting for the precepts of democracy, not the least of which is the right to free choice of political credo. The involuntary return of prisoners to the North Koreans is an absolute violation of that right, and would certainly result in a tremendous loss of face for us throughout all of the civilized world. As a matter of fact, my own faith would be reduced considerably . . . . I fear that political pressure will ultimately demand the involuntary return of the prisoners . . . . are we only a nation of little people? . . . .

Love, Bill

NOTE: Will we permit the pygmies in Washington to sell Bill's birthright, and ours, for a mess of putrid, political porridge? Have we gone *soft*, making deals without principles, fighting war without victory, paying blackmail for phony and fleeting "security"? Find the answer in *your* mirror and proclaim it with *your* vote!—H.H.H.

An "Aditorial" by the President of General Alloys Co., "Oldest and Largest Exclusive Manufacturers of Heat and Corrosion Resistant Alloy Castings" — Boston, Mass.

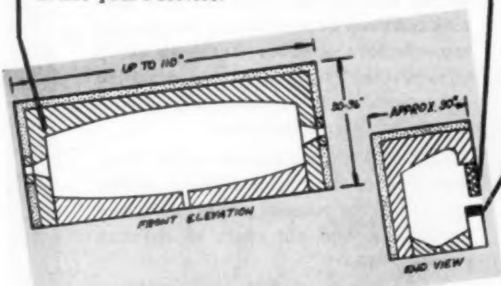
THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

here's how TO GET <u>LONGER LIFE</u> FOR YOUR FORGE FURNACE LININGS

Taylor Sillimanite (TASIL) refractories prolong service life of 50 furnaces operated by an automotive parts manufacturer.

TASIL HYDROCAST—the hydraulic-setting castable refractory for service up to 3000° F.—is used to cast the backwall, end walls, burner openings and roof. Mix Hydrocast with water and pour in place like concrete—your special shapes are in the bag! TASIL Hydrocast main linings in these furnaces are giving a minimum of one year's service.

TASIL TILE are used for the front arch, where resistance to spalling from thermal shock or rapid heating is required. TASIL tile generally last from 2 to 6 months, depending on the severity of the furnace operation. This is 4 to 6 times the life of fireclay tile.



TAYCOR BRICK (90% Al_2O_3) were selected to form the bottom of the slot because of their excellent resistance to abrasion and attack from iron scale. Fire brick in this location had to be replaced weekly—TAYCOR brick average three months. Very little scale or slag stick to the TAYCOR brick and that which does cleans off easily.

CROSS SECTIONAL VIEWS OF FORGING FURNACE

- RAMMED CHROME ORE
- TASIL HYDROCAST #402
- TAYCOR BRICK
- TASIL TILE
- FIREBRICK OR INSULATING BRICK
- FIREBRICK

If your heavy-duty or high-speed heating and heat-treating furnaces still require too-frequent shutdowns for re-lining, investigate the advantages of Taylor Sillimanite. Write direct, or contact the Taylor Representative in your area, for recommendations on your furnace problem. No obligation, of course.

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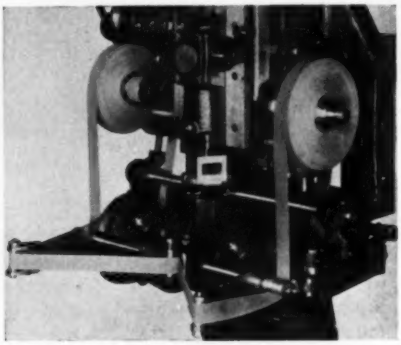
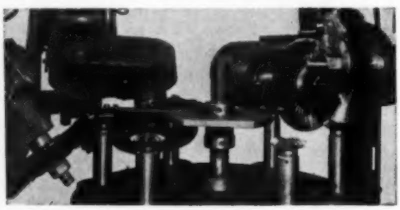
FOR CIVILIAN AND DEFENSE PRODUCTION

• *Provide effective solutions to problems of high production* . . . . POLISHING . . . . BUFFING . . . . GRINDING WIRE BRUSHING . . . . DE-BURRING . . . . MICRO-FINISHING



● ABOVE: Close-up of ACME Jet Blade Polishing Machine for longitudinal polishing. Indexes blades from coarser to finer grit finishes. Made in various sizes. ACME Edging Machines (not illustrated) are available for automatic blending and polishing of leading edges of airfoil for jet blades.



● ABOVE: ACME 6-station, 4-head rotary wire brushing for pinion gears. Machines of this type available in various sizes and arrangements for defense production.

Acme Automatics cut cost and increase production on many operations such as radius blending, grinding armor plate, thread clearing, wire brushing, micro-finishing and automatic rotary and continuous indexing of various operations, as well as on automatic polishing and buffing of all sizes and shapes of parts used in defense production.

Half a century of progressive experience and development in this specialized field of machinery design and manufacture enables Acme to serve you efficiently in supplying machine arrangements to meet the special demands of your production.

Close-up photos shown at left illustrate two of the many efficient ACME special arrangements that increase production and cut costs in defense production.

Our new plant offers enlarged capacity and facilities for engineering, experimental processing, development and tryouts which can be a valuable aid to manufacturers in defense industry.

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55 W. 42nd St., New York 18—CHickering 4-2713
Ralph H. Cronwell
482 Burton Ave., Highland Park, Ill.—Highland Park 2-4263
Donald J. Billings
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